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BULLETIN OF THE TORREY BOTANICAL CLUB
VOL. 73, NO. 3, PP. 217–218 MAY, 1946

PROPOSED NAMES FOR THE PHYLA OF ALGAE

GEORGE F. PAPENFUSS

Although the term Thallophyta[1] is still useful as the inclusive name for a number of groups of plants of a certain morphological level, it has long been recognized that this name has become obsolete as a phyletic designation.

The algal component of the Thallophyta has been variously subdivided by different writers into a number of phyla. The system which for a long time was followed was that of Engler in the third and subsequent editions of Engler and Gilg's *Syllabus der Pflanzenfamilien*. Finally, Engler arranged the algae under nine phyla as follows: Schizophyta, Flagellatae, Dinoflagellatae (including possibly his Silicoflagellatae), Bacillariophyta, Conjugatae, Chlorophyceae, Charophyta, Phaeophyceae, and Rhodophyceae.

With the advance of knowledge it has become increasingly clear that this arrangement is also to be abandoned. At present there are two systems: That of Pascher (1931[2] and earlier papers), which has become well-known through its adoption, with slight modification, by Smith[3]; and that of Fritsch as outlined in the first volume of his work, *The structure and reproduction of the Algae* (1935, pp. 4–11).

Pascher divides the algae into the following eight phyla: Chrysophyta, Phaeophyta, Pyrrhophyta, Euglenophyta, Chlorophyta, Charophyta, Rhodophyta, and Cyanophyta. Fritsch on the other hand does not assign the algae to phyla, but arranges them under eleven classes as follows: Chlorophyceae, Xanthophyceae, Chrysophyceae, Bacillariophyceae, Cryptophyceae, Dinophyceae, Chloromonadineae, Euglenineae, Phaeophyceae, Rhodophyceae, and Myxophyceae. Both Fritsch and Smith look upon *Chara* and its allies as forming a category of the true green algae.

Inasmuch as class is a category below the level of phylum and since there, at present, is no justification for looking upon all algae as composing a single phylum, the system of Fritsch does not constitute a complete and well-rounded arrangement.

The system of Pascher thus remains as the one which is most acceptable. The phyletic names used by him were recently criticized, however, by Papenfuss[4] on the ground that they do not contain the old and well-established

[1] First proposed by Unger in 1838, according to Just (Bot. Rev. 11: 302. 1945), but brought into prominence by Endlicher in his *Genera Plantarum* (1836–1840).

[2] Beih. Bot. Centralbl. 48: 317. 1931. Some of the names used by Pascher were first proposed by Wettstein (*Handbuch der systematischen Botanik*, 1901).

[3] Cryptogamic Botany, Vol. 1. 1938.

[4] Madroño 7: 226. 1944.

[THE BULLETIN for March–April (73: 103–216) was issued March 15, 1946.]

connotation "phykos." Another objection lies in the designation *Chlorophyta* as the exclusive name for a group of algae.

Since names are a convenient means of referring to things, it is desirable that they be distinctive. The appellations of Pascher fulfill this requirement to a large extent in that they terminate in "phyta" and therein conform to the phyletic designations of other plant groups.

If the names of algal phyla contained the connotation "phykos" also, they would have the added merit of being explicit as to the kinds of plants to which they apply. It is with this objective in mind that the following modifications of the designations of Pasher are proposed: Chrysophycophyta, Phaeophycophyta, Pyrrhophycophyta, Euglenophycophyta, Chlorophycophyta, Charophycophyta,[5] Rhodophycophyta.[6]

In making these names the Greek word φῦκος, meaning seaweed, is taken as synonymous with alga, as has been the custom for a long time. It is true that at first glance the names seem ponderous but with the accepted practice of accenting the antepenult the pronunciation is both easy and euphonious, for example, Chloro · phy · co phy · ta.

It may be argued that these designations are outlawed by the rule of priority. The same objection could, however, be raised also with respect to certain of the names of Pascher or of some of those currently used for certain other plant phyla. If the rule of priority were strictly adhered to, the name Thallophyta would have to be retained for one of the phyla of lower plants. For the same reason the designation Stelophyta (cf. Just, op. cit.) would be invalid as a name for vascular plants; or the name Bacillariophyta may have to be retained for Pascher's Chrysophyta, which phylum, however, includes, in addition to the diatoms (Bacillariophyceae), two classes of organisms which in no way could pass as diatoms.

It is clear that the retention of outmoded phyletic names would not be in keeping with present-day knowledge of plant relationships and, as has been pointed out by Just (op. cit.), it becomes desirable that the question of the names of higher categories be reviewed at the next International Botanical Congress. Furthermore, it seems desirable that legislation which may be passed relative to these designations be flexible enough to permit revision of the names in the light of further knowledge concerning plant phylesis.

UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA

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[5] In agreement with Pascher and others this group of algae is considered sufficiently distinct from the true green algae to deserve the rank of phylum.

[6] The blue-green algae or Cyanophyceae are taken as constituting a class in the phylum Schizophyta.

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A CURIOUS FUNGUS ON OPUNTIA

B. O. DODGE

While studying fungous diseases of cacti from Florida some years ago, I very frequently came across the tiny "fruiting bodies" of a fungus which was quite unlike any species known to me. Thaxter, Peck, or von Hoehnel, with their great knowledge of bizarre forms of fungi, might have recognized this fungus if it had been brought to their attention and so would have been able to point out just where it had been described long ago. For me it was not possible to place it even in a Class either among minute species of the higher forms or among the Fungi Imperfecti. The fungus was clearly not very destructive to its host, *Opuntia ammophila*. Since I hoped to find eventually where it had been described and to learn something more about its morphology and life history, it was not mentioned in the short articles on *Opuntia* diseases which I published at that time (1937–1939). Miss Bass Guttman, at my request, made a few sketches from slide mounts which I had hastily prepared for the purpose. Some of these sketches, together with photographs taken recently for me by Mr. E. N. Mitchell of our staff, are reproduced in figures 1 and 2 herein.

The little fruiting bodies, as they may be called for convenience, consist of two parts, a stalk and a cap. The stalk is dark brown, about 200–500 μ in length, tapering from about 40 μ in diameter at the base to about 20 μ at the top. It is curiously made up of segments or joints simulating in miniature the fertile stalks of the common horsetail, *Equisetum arvense*. In both plants the joints can be easily separated. The drawings and photographs (figs. 1, 2) show that the rind, or outer layer, of the top segments of the stalks either can be slipped off from the core, which is solid, or it develops after the cap is dislodged. The hyphae which compose the outer wall as well as those of the core seem to grow more or less parallel up the stalk. Since the hyphae of the rind at least of one segment do not continue straight into the next segment, it may be (although I have no direct evidence for this) that each segment, as it forms, develops its own cap, which as it matures is pushed off or thrown off. After this occurs the stalk cells may proliferate or regenerate and so grow up to make another segment, which in turn would develop a cap, throw it off, and send up a third joint, and so on. The photographs show at least ten joints in some of the stalks.

One reason why one finds so many little caps lying directly in contact with the surface of the cactus pad, entirely apart and at some distance from the stalks on which they originally grew, is the ease with which these caps

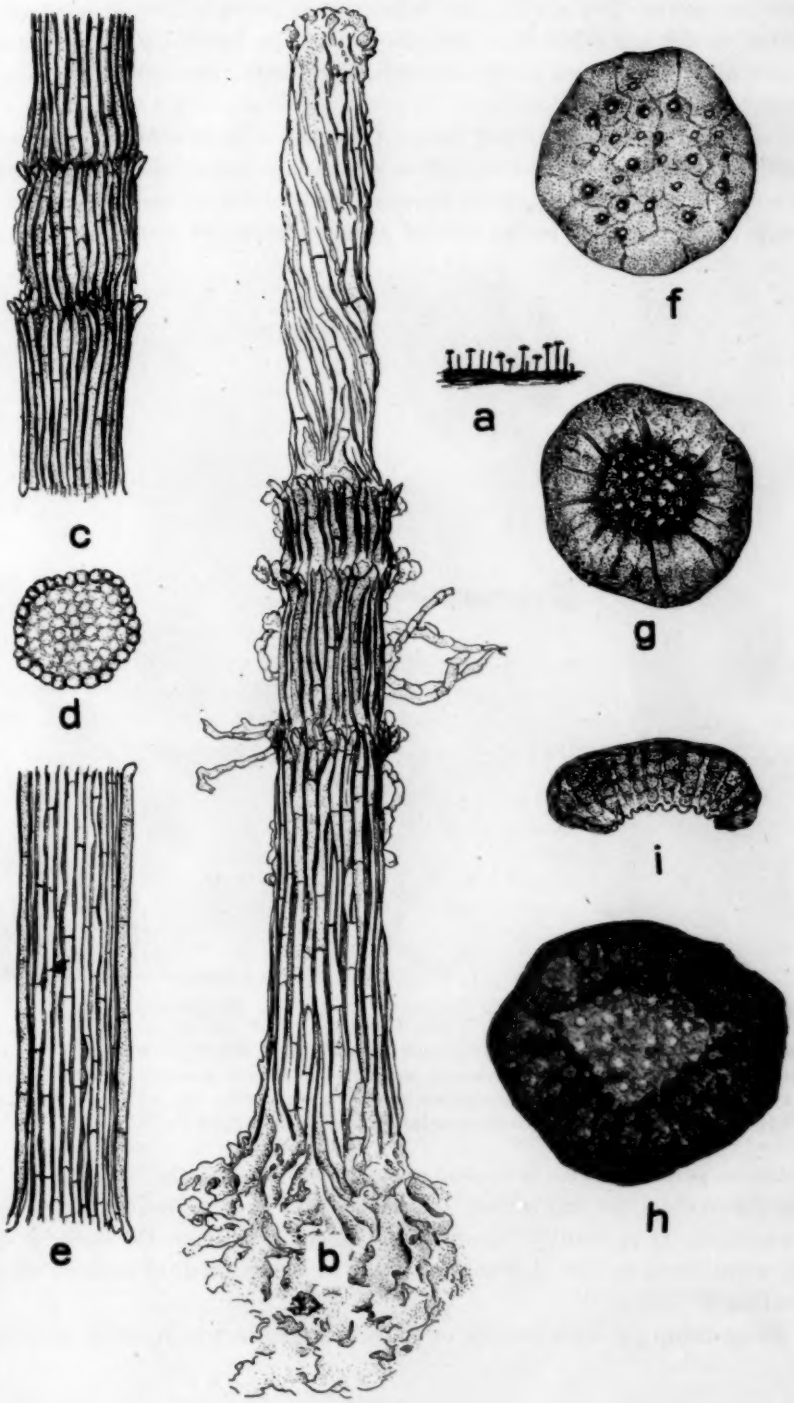
can be dislodged and so go sailing off to land elsewhere. We found on the cactus pads, as they arrived from Florida, many stalks which had lost their caps. It may be that through the cooperation of the thrust of the upward-growing stalk-hyphae and the highly elastic shell of the attached cap, the latter would be thrown off with some force when the connection between cap and stalk is broken. Anyway, this would be good material for observation and experimentation on the discharge of propagating bodies.

The caps are dark brown, almost black. They measure 50–80 μ in diameter; they are about 20–25 μ in thickness, somewhat concavo-convex in shape, the edge thick, something like a minute doughnut, except that the hole extends only partly through. This depression represents the place of attachment of the cap to its stalk. Those who are familiar with *Boleti* and have pulled a stalk from its pileus will have no trouble in visualizing the shape and parts of our little fungus.

While mounts of caps show that the outer layer or covering is hard, dark brown, and brittle, it seems to be perforated here and there, giving a sort of pepper-box effect. Whether these bright spots are holes or only thin places in the chitinous outer layer is uncertain (fig. 1*f*). Crude cross sections of caps (fig. 1*i*) show rows of cells, about four cells to the row, extending out from the border of the depression on the under side. Possibly these radiating rows originate from the core cells of the stalk. Whether the common number four in each of the rows has any significance is doubtful.

Pure cultures of this fungus are very easily obtained if one simply removes a cap directly from its stalk with a wet needle and places it on the surface of an agar medium in a plate. Within two or three days branched septate hyphae grow out from the cap. From which cells of the cap these germ tubes actually arise was not determined. Transfers can be made to tube cultures by cutting off the ends of these hyphae or by transferring the whole cap with its outgrowths, if there appear to be no contaminants present. After three or four weeks one finds that the fungus has developed real stalks which grow up from small mounds or knots of mycelium. These stalks may appear singly or in groups of five or six. In only a few cases did typical caps develop sufficiently to prove absolutely that we had pure cultures of the fungus taken

FIG. 1. *a*, Habit sketch to show *Tretopileus Opuntiae* as it grows on the edge of a cactus pad, seen with a binocular dissecting microscope. The caps of some stalks have been dislodged. *b*, A stalk with four segments; the outer layer or shell of the top segment either had been slipped off or had not formed as yet. *c*, Surface view of one short segment with details seen by the artist. *d*, *e*, Cross and longitudinal sections showing the core and rind of a segment. *f*, Cap seen from above and showing the pinhole-like spots. *g*, A similar cap viewed from the under side, showing the depression where it had been detached from its stalk. *h*, Another view from below showing the pinholes in the upper surface of the cap as the microscope was adjusted to bring this surface into focus. *i*, Crude section of a cap showing the rows of cells extending outward from the region of attachment of cap to stalk. *b*–*h*, ×550.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from the cactus. The stalks that developed in these cultures were not segmented or jointed. This may indicate that stalks made up of segments develop only with the successive formation of caps, one after the other, as suggested previously.

It may be that in nature, under certain conditions minute spores are finally developed inside the cap, after which they are sifted out through the pores. On the other hand, these pores or thin places in the outer wall may be a provision for the emergence of germ tubes which would otherwise be

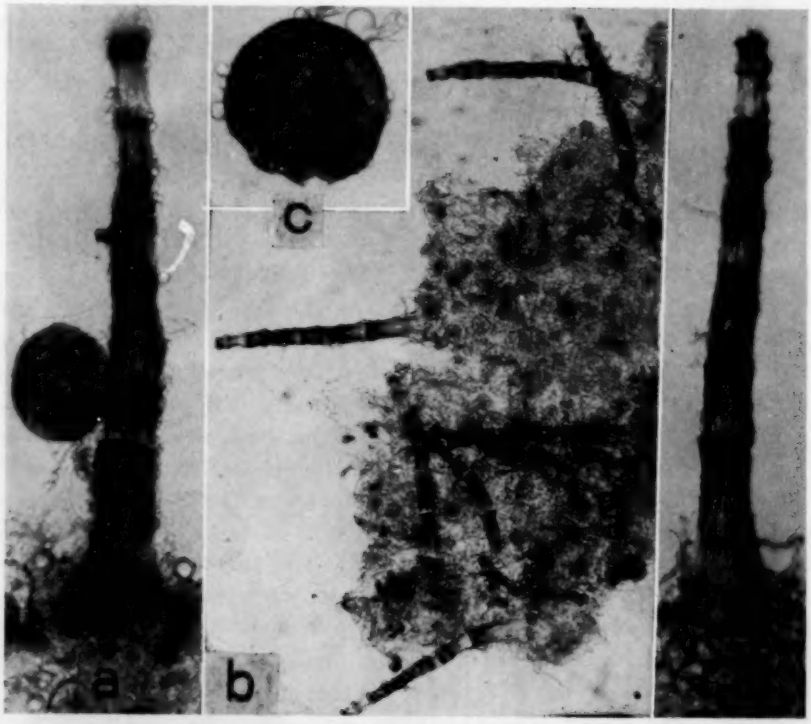

FIG. 2. *a*, Photograph of a stalk having nine segments; the dislodged cap viewed from the under side is at the left below. × 200. *b*, Fragment of the cactus pad bearing eight stalks of the fungus. The caps, if originally present, were dislodged when the mount was made. × 75. *c*, A rather small cap viewed from the under side showing faintly the radiating rows of cells seen through the chitinous outer cover of the cap. × 350. *d*, The stalk at the left center in *b* is shown here more enlarged. It has ten segments. × 200.

unable to penetrate the chitinous outer membrane of the cap. So far as I have discovered, the cap serves, just as we find it, very well as an organ of propagation. It is readily blown off or discharged from its stalk, perhaps with some force, so that it is carried away to a new feeding ground where it germinates.

Many fungi produce bulbils or minute sclerotia which serve in place of

spores. Liverworts develop gemmae, and the editor reminds me that some lichens produce soredia. Perhaps our fungus, in the stage in which we find it, is the sterile form of some lichen like *Calicium*. The coarse brown cells at the joints of the segments of the stalk of our fungus sometimes grow out freely a short distance into the air. I have frequently found a few spores, usually brown and two-celled, associated with similar coarse hyphae around the base of the stalk. Furthermore, one sometimes finds cactus pads bearing short bristle-like coarse brown hyphae arising either singly or in groups of three or four from the pads. One at first easily mistakes these bristles for stalks of our fungus. Microscopic examination, however, proves that these bristles are composed of single hyphal threads made up of rows of thick-walled cells. We have in the Gasteromycetes the genus *Myriostoma* and a *Calvatia* with a well-defined stalk. These similarities are, of course, merely analogies or accidental parallelisms.

I am indebted to Dr. David H. Linder for suggestions on the group to which this fungus might be assigned. He was unable to place it, however, without further information on its life history. In order that reference may be made to this fungus, it is named and described below. The name (suggested by Dr. H. W. Rickett) refers to the pores or thin places in the shell of the cap.

Tretopileus Opuntiae Dodge, gen. & sp. nov. Fructibus per areolas discolores segmentarum cactorum dispertis, e mycelio plus minusve subcuticulari exorientibus; stipite articuloso segmentis 1–10 aliquando separabili, 200–500 μ longo, 20–40 μ crasso, cortice e crasso-tunicatis brunneis hyphis septatis secundum longitudinem stipitis dispositis confecto, medulla e tenuitunicatis cellulis similiter dispositis contecta; pileo 60–80 μ diametro, 20–30 μ crasso, concavo-convexo, membrana superficiali obscure brunnea, dura, chitinea, pluribus poris vel areolis subtilibus munita, cellulis interioribus seriatim radiatimque dispositis, facile ab stipite disjungendo.

On pads of *Opuntia ammophila* and related species, Fort Pierce, Florida, 1937–1939.

Since it is not convenient to continue a study of this fungus, the above notes are put on record in the hope that some mycologist may become interested and complete the story, if it has not already found its place in mycological literature.

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FURTHER CONSIDERATION OF GLANDULAR LEAF HAIRS OF TOBACCO AND OF THEIR SIGNIFICANCE[1]

FREDERICK A. WOLF

From previous studies involving hairiness of oriental varieties of tobacco (Wolf & Jones 1944, Bentley & Wolf 1945), it was concluded that aroma seems to be traceable primarily to the exudate from glandular hairs, that different varieties, when grown under similar conditions, differ in hairiness, and that both hereditary and environmental factors are interdependent in controlling the population of leaf hairs. Apparently the range of variability is governed by hereditary factors, and environment determines the position of the variant within this range. Moreover it was concluded that a measure for evaluating *potential* amount or quantity of aroma of a given leaf before curing is provided by the two correlated criteria: (a) number of hairs per unit of leaf surface, and (b) total number of hairs per leaf. These two criteria may be readily determined from direct microscopic examination of green leaves. Unfortunately means are not yet at hand for determining the accuracy of such evaluation by checking it against *actual* quantity of aroma possessed by leaves after they have been cured and aged. It should be emphasized that methods for measuring directly the quantity of aromatic material or the amount and kind of specific odorous constituents are quite unknown, except by appraisal through the sense of smell. To devise some operable means does not seem to present insuperable difficulties, since it should be possible to remove the volatile constituents from cured leaves by distillation or extraction with solvents and then to isolate them and make quantitative measurements.

Since the amount and kind of aroma are of major importance in appraising quality of oriental tobaccos, further consideration was given to means of modifying the population of glandular hairs. The results of experiments obtained during the past two seasons with selection and hybridization, as well as with experiments concerning variations in the spacing of plants and variation in light are believed further to contribute to an understanding of the problem of aroma, and accordingly are presented at this time.

[1] These investigations were financed, in part, by the General Education Board. Grateful acknowledgment is made for assistance rendered in the conduct of these investigations by Nancy J. Bentley and Vera Rudin, Graduate Assistants at Duke University. Thanks are also extended to Dr. Paul M. Gross for critical reading of the manuscript, although the author is solely responsible for the interpretations and conclusions herein.

MATERIALS AND METHODS

In general, the procedures employed were identical with those described in a previous report (Bentley & Wolf 1945). The analyses involved plants grown in fields at the Tobacco Experiment Station, Oxford, N. C., as well as supplementary analyses of plants grown under glass at Durham, N. C. Plants found to have leaves more hairy than others of the same variety were selected as seed stock. For comparison non-selected plants, taken completely at random, were used as a seed source.

Plants similarly selected from the F_2 generation constituted the parents used to determine hairiness of crosses between varieties. Their progeny was compared with that of non-selected F_2 parents.

In tests concerning the influence of spacing, the intervals "between rows" and "within rows" were arbitrarily chosen. These spacings were (1) like those commonly employed with flue-cured tobacco, (2) like those commonly used with oriental tobacco, and (3) with twice as many plants per unit of area as in the common practice with oriental tobacco. In these tests were employed representatives of three types of oriental tobacco. These were Stanimaka (Kavalla type), Ayassolouk (Smyrna type), and Broussa (Samsoun type), as well as one flue-cured type, Cash.

The experiments concerning effects of light of different intensities were performed upon both field-grown plants and plants grown under glass. Plants exposed to normal illumination were compared with those grown under artificial shade. Use was made of a shade tent built of framing and covered with seed-bed cloth to reduce light-intensity, and comparative light measurements were made with a Weston photometer.

INHERITANCE AND GLANDULAR HAIRS OF TOBACCO

There exists a rather meagre background of observations on inheritance of pubescence or hair-coatings among plants. Paulesco in 1900 (vide Netolitsky 1932, p. 11, 12) was among the earliest investigators to show that the hair pattern of hybrids is a mixture of that of both parents. A similar conclusion was reached by Wolf from observations on *Potentilla*, by Netolitsky on *Rubus*, and by Baros on *Verbascum* (Netolitsky l.c.). Imai (1926) crossed a smooth-stemmed morning glory, *Ipomoea hederacea* Jacq. (*Pharbites Nil* Choisy), with a hairy-stemmed one. All plants of the F_1 generation were hairy but in the F_2 generation a ratio of 3:1 of hairy-stemmed to smooth-stemmed individuals was obtained. A similar dominance of hairiness over glabrousness in sesame, *Sesamum indicum* L., to give a 3:1 ratio in the F_2 generation, was reported by Langham (1945).

The population density and length of hairs on *Hyocyamus niger* L. are at least partly determined genotypically, according to Goddyn (1926).

As regards tobacco, previous observations (Bentley & Wolf 1945) showed

TABLE 1. *Results of Selection as a Means of Increasing Hairiness*

Year	Increase in leaf area, cm.², of selected over non-selected, %	Increase in number of hairs per leaf, of selected over non-selected, %	Increase in number of hairs per unit area of selected over non-selected, %
1944	34	31	1
1945	23	38	12

the existence of varietal differences in hairiness and indicated that tests should be conducted to determine the possibility of increasing hairiness by selection. Accordingly selections were made, using the varieties Broussa, Dere, Djebel, Hendek, Katarini, and Yenidge. The average composite results, expressed as percentage differences between selected and non-selected plants, are shown in table 1.

These data do not reveal actual differences but are comparative, and show that selection provides a means of increasing hairiness. They give no indication however of seasonal effects. It should be indicated that the 1945 season was one having very excessive rainfall and an unusual proportion of overcast days. Seasonal effects become apparent when it is pointed out that an average leaf of progeny of selected plants of the varieties mentioned above bore 74 per cent as many hairs in 1945 as in 1944. An average leaf of the progeny of non-selected plants of the varieties Ayassolouk, Ghimpati, Jalomita, Stanimaka, and Xanthi-Yaka bore 60 per cent as many hairs in 1945 as did non-selected plants of these same varieties in 1944. This difference of 14 per cent seems ascribable to selection. It must be appreciated however, in the light of other experiments and of observations extending over three sasons, that, in selecting seed-stocks, account must be taken not only of seasonal influences but of the interrelation and interdependence of vigor, date of maturity, and leafiness of plants, together with leaf size, and hair population per unit of leaf surface.

The influence of selection among hybrids was sought by making selections of the F_2 generation and then comparing the progeny of selected and non-selected stocks. The hybrids involved Yenidge as the pistillate parent,

TABLE 2. *Results of Selection of Parent Stock among F_2 Generation on Hairiness of Progeny*

Year	Parents	Relative leaf size, F_2	Relative number hairs per leaf, in thousands	Relative number hairs per cm.²
1945	Yenidge ♀ × Stanimaka ♂	Selected: non-selected = 80.6: 100	Selected: non-selected = 112: 100	Selected: non-selected = 129: 100
1945	Yenidge ♀ × Ayassolouk ♂	Selected: non-selected = 89: 100	Selected: non-selected = 105: 100	Selected: non-selected = 114: 100

and Stanimaka, in one case, and Ayassolouk, in the other, as the staminate parent. The results are assembled in table 2.

It is quite evident that the progeny of the more hairy parents was in turn the more hairy, results entirely in accord with well established findings on other genera of plants. The extent to which selection and hybridization can be employed, however, in actual field practice, to improve quality, can be known with finality only by extensive comparative trials, and appraisal of the tobaccos grown must be made after they have been fully aged.

SPACING

Bentley & Wolf (1945) have studied the relation between spacing and hairiness, using one oriental variety, a Burley type, and a flue-cured tobacco. The results were recorded as differences in leaf size and total leaf area of an average plant, and also as differences in number of hairs per plant, per leaf, and per unit of leaf surface.

In all studies, by other investigators, involving the effects of spacing on growth of the tobacco plant it appears that the primary consideration in appraisal of results has been "yield per acre." Although yield is a most important practical consideration, largest yield is not necessarily correlated with best quality. In fact, there is reason to believe that quality, in some tobacco-growing areas, has been sacrificed in favor of quantity. This would indicate that in experimental studies of spacing the objective should be to produce the largest possible yield and having the largest proportion of the superior grades.

Although a rationale for proper spacing no doubt exists it seems never to have been sought or established. With the idea of seeking to establish such basis for proper spacing practices, two experiments were performed during the past season. The one was essentially a repetition of a test made in 1944, except that it involved different varieties of tobacco, and the other involved further intensification of competition between plants.

In the first experiment the interval between widely spaced plants was 24 inches in 48-inch rows, and those between closely spaced ones was $5\frac{1}{2}$ inches in 20-inch rows. The oriental varieties chosen were Ayassolouk and Broussa, and Cash was the flue-cured variety used. Data on average analyses of five plants of each kind are assembled in table 3.

Under these conditions the widely spaced plants had the larger leaves with the larger number of hairs per leaf. Moreover the population of hairs was less dense on widely spaced plants than on closely spaced ones, except in Stanimaka. An interpretation of data to be presented later (table 5) appears to be applicable in explaining these findings with Stanimaka. The degree of accordance with results from a similar experiment conducted in 1944 (table 4 of a previous report) is best shown by comparing the data as arranged in the accompanying tabulation (table 4).

TABLE 3. *Spacing and Hairiness of Entire Plants*

Variety	Spacing	Average total leaf area per plant, cm.²	Average total hair population, per plant, on lower leaf surface, in thousands	Average size of leaves, cm.²	Average number of hairs per leaf on lower leaf surface, in thousands	Average number of hairs per cm.² on lower leaf surface, in thousands
Ayassolouk	Widely spaced	9,139	9,811	268.9	289.6	1.07
	Closely spaced	2,518	5,305	90.4	168.4	1.86
Broussa	Widely spaced	7,722	11,216	257.9	377.6	1.42
	Closely spaced	4,136	7,535	141.4	256.8	1.81
Stanimaka	Widely spaced	11,361	11,057	408.1	401.1	0.98
	Closely spaced	6,027	5,983	195.5	195.1	1.00
Cash	Widely spaced	11,053	12,587	516.6	588.3	1.12
	Closely spaced	3,257	7,258	158.1	352.0	2.22

To prepare table 4 an average number was first obtained for comparable structures of widely spaced and closely spaced plants. This number for the latter kind, divided by that for the former, yielded the percentage relationships recorded. When thus presented, the magnitude of differences between closely spaced and widely spaced plants is found to be of the same order each year. The data show that the closely spaced plants had approximately 40 per cent as much leaf area as widely spaced ones and 60 per cent as many hairs, but there were from 30 to 50 per cent more hairs per unit of leaf surface.

A second experiment, involving further intensification of competition, was devised to seek a reason for these differences in response to spacing. In

TABLE 4. *Comparative Effects of Spacing. Trials in 1944 and 1945.*
(Data on widely spaced plants regarded as 100)

Structures compared	Year	
	1944	1945
Proportionate leaf area of closely spaced to widely spaced plants	45.6	40.5
Proportionate total hair population per plant of closely spaced to widely spaced plants	61.2	58.3
Proportionate leaf size of closely spaced to widely spaced plants	48.4	40.4
Proportionate hair population per leaf of closely spaced to widely spaced plants	59.9	57.2
Proportionate density of hairs per cm.² of closely spaced to widely spaced plants	130.1	149.5

this instance each variety was spaced as in the previous experiment and in addition each variety was so planted as to have approximately twice as many plants per length of row as occurred in the closely spaced rows. Leaves from the median stalk region were taken for analysis, and average results for the three spacings are presented in table 5.

The most noteworthy features in table 5 for each variety are: (1) that the plants, spaced most closely, have the smallest leaf area and bear the smallest number of hairs; (2) that the smallest leaves do not have the densest hair population; and (3) that each variety responds to competition to a different extent. These results indicate that an optimum spacing interval "between rows" and "within the rows" exists, and should be sought experimentally for each variety. These intervals are determinable only from results

TABLE 5. *Effect of Spacing on Leaf Size and Hairiness*

Variety	Spacing, inches	Average leaf area, cm.²	Average number of hairs per leaf in thousands	Average number of hairs per cm.,² in thousands
Ayassolouk	48 × 24	372.6	293.8	0.79
	20 × 5½	148.8	169.6	1.15
	20 × 3	89.9	94.6	1.05
Broussa	48 × 24	348.0	427.6	1.20
	20 × 5½	187.9	235.4	1.24
	20 × 3	90.5	104.6	1.15
Cash	48 × 24	550.4	483.5	0.87
	20 × 5½	210.8	350.0	1.63
	20 × 3	124.1	190.1	1.53

of series of trials, and hairiness and correlated leaf size may be used as a basis of judgment. It cannot be too strongly emphasized that per unit area population of hairs and leaf area must be considered as a unit in such trials. Were this done it should show that both yield and quality are optimum when the plants are suitably spaced. To space the plants more widely that optimum might be expected to increase yield at the sacrifice of quality or to space them more closely might adversely impair both yield and quality. Should these conclusions be verified by future extensive field trials, then hairiness constitutes a criterion for appraising a balance in the growing plant between quality and yield. Moreover the investigator then has, for the first time, a means for determining under what conditions optimum hairiness may be produced.

In the foregoing experiment, there was a detectable difference in kind of aroma, as measured by the sense of smell, among the leaves of each variety when differently spaced. It may be assumed that each of the factors entering into the complex called spacing operates to modify not only population density of glandular hairs, but at the same time the amount and kind of

material synthesized by the glands. The net result should be differences in proportion of ethereal oils produced, and hence in differences in quality of aroma.

LIGHT

That hairiness varies in response to differences in light and moisture is a general observation, known by many of the older students of plants. De Candolle (1841) concluded that "non-glandular hairs are, in general, rare in plants which grow in the shade, or in rich and moist places" and "are more abundant, generally, in those which grow in warm and dry places, much exposed to the sun." Vesque and Viet (1881) showed that the number and length of hairs on leaves is increased by the stimulus of light and of dry air. Mer (1883) also concluded that exposure to light and dryness favors increase in hairiness.

Yapp (1912), from observations on *Spirea ulmaria* L., concluded that "(b) On the erect flowering shoots of adult plants there is a regular succession of glabrous, partially hairy, and completely hairy leaves. The earliest radical spring leaves are glabrous, the cauline leaves hairy. (c) The non-flowering shoots of adult plants produce only radical leaves. The earliest of these are glabrous. Subsequently, the successive leaves exhibit increasing hairiness up to June or July, after which they are decreasingly hairy, till finally glabrous leaves are once again produced in autumn . . . seasonal periodicity in the production of hairs is a widespread phenomenon." He regards increased hairiness as a xeromorphic response, i.e., the result of factors or conditions that impose on the plant a need for increased economy of water. There are those who would question these interpretations by Yapp.

From perusal of pertinent reports of ecological investigations one is forced to conclude that there exists a paucity of experimentation on the extent to which hairiness is modified by environment and how hair-coatings, in turn, modify plant activities. That hair-coatings decrease water loss appreciably was brought into question by Sayre (1920). He removed the hairs (non-living and non-glandular) from mullein, *Verbascum thapsus* L., and then exposed one set of these plants to light and wind and another to light and still air, finding that there were no marked differences in water loss. The reason assigned by him for this lack of dissimilarity is that amount of water lost through the cuticle is small in comparison with that lost from internal tissue (mesophyll).

The present field experiments bearing on the influence of light involved comparison of artificially shaded plants with those grown fully exposed to normal illumination. The light intensity under the artificial shade was reduced from 40 to 60 per cent, as measured with a photometer. Comparative data obtained from analyses of leaves of these two groups of plants are shown in table 6.

TABLE 6. *Comparative Effects of Artificial Shade and Normal Illumination on Hairiness.*

Variety	Average leaf area, cm.²		Hairs per leaf, in thousands		Hairs per cm.²	
	Shaded	Not shaded	Shaded	Not shaded	Shaded	Not shaded
Ayassolouk	130.5	148.8	112.2	169.6	860	1150
Broussa	128.8	187.9	135.3	235.4	1050	1240
Cash	134.2	210.8	214.7	350.0	1600	1630

It may be seen from table 6 that the leaves of shaded plants were smaller and had fewer hairs, although the population of hairs per unit area was larger than on the non-shaded plants. Actually the leaves of shaded plants were approximately two-thirds as large as those in full light, and the hairs were about three-fifths as numerous, whereas the population density of hairs was about 10 per cent greater than that of the plants in full sunlight.

Since shade-grown leaves of many species are known to be larger than those grown in full light it was anticipated that the shaded leaves would have been the larger. Both intensity and total amount of light available to these closely spaced plants may have been insufficient, and therefore the unexpected outcome may be attributable properly to inadequacy of light. Be that as it may, the results are in accord with previous studies in showing that decreased illumination may decrease the total hair population per leaf.

In another experiment comparison was made of hairiness of field-grown Katarini tobacco leaves, developed in early summer, with that of sucker leaves that developed on stubbles during the latter part of the growing season. Comparison was also made, using the same variety, of hairiness on leaves that developed on suckers from stubbles transplanted into the greenhouse in late summer. One set was exposed to normal greenhouse light and intensity of light for the other set was reduced approximately 75 per cent

TABLE 7. *Effects of Light on Hairiness of Leaves of Katarini Tobacco*

Growth conditions	Average leaf area, cm.²	Average number of hairs per leaf, in thousands	Average number of hairs per cm.²
Field grown, during summer	192.0	170.8	890
Suckers (field grown) arising from stubbles in late summer	83.2	123.1	1360
Suckers arising from stubbles transplanted into greenhouse. Full light	93.3	84.3	904
Suckers arising from stubbles transplanted into greenhouse. Light reduced by shade tent	92.3	64.1	695

by a cloth-covered shade tent. The comparative measurements from this experiment are given in table 7.

The most significant features in table 7 are those dealing with differences in average total number of hairs per leaf. The leaves of field-grown suckers had approximately 70 per cent as many hairs as did leaves grown during early summer. Moreover, the leaves on suckers grown under full exposure to light in the greenhouse had about 70 per cent as many hairs as did those of sucker growth in the field, and the leaves of suckers under the screen in the greenhouse showed marked further reduction in hairiness.

Since reduction in hairiness of tobacco leaves occurred in all cases in which light intensity was reduced, it is concluded that light may be made to function as the dominant factor in modifying hairiness.

GENERAL CONSIDERATIONS

The fact that a knowledge of hairiness of tobacco leaves may be employed to evaluate aroma becomes significant in the light of evidence that both quantity and quality of aroma are controllable and modifiable to a considerable degree. There is reason to believe that varieties of tobacco having aroma superior to that of varieties now in hand can be developed by selection and hybridization. Support for this belief arises from the fact that several kinds have already been made more uniform by selection, and these selected strains have shown themselves superior in vigor, leafiness, and leaf size. They are, at the same time, more hairy than progeny of non-selected stocks and it seems highly probable that they will prove to be more aromatic. Additional support for anticipating that continued improvement in kinds of tobacco can be effected stems from results of genetic studies with other species of plants. Such studies in their entirety contain nothing to counterindicate the possibility of further improving the aromatic potentialities of oriental varieties of tobacco.

The experiments thus far conducted are in accord in showing that tobacco plants produce leaves differing in hairiness as a response to differences in spacing and to differences in nutrients. Observations with other kinds of plants provide additional support for the existence of such relationship of responses to environment. Raunkiaer (1934), for example, noted that very hairy-stemmed rye plants occurred more frequently in portions of the field having the drier soils. Moreover the least hairy plants ripened appreciably earlier than the densely hairy ones. As previously noted, hairiness and maturity in tobacco seem to be similarly correlated. Again, Kisser (1927) found that hairiness of wheat is modified by the presence of certain salts. Plants, in solution culture, supplied with Ca, Mg, or Na were less hairy than those supplied with distilled water only. It would seem to follow, since hairiness, and hence aroma, can be changed by spacing and by nutrition, that hair analyses should be employable to determine proper practices of spacing and of application of fertilizers for oriental tobaccos.

It may be presumed that there exists a relationship of moisture to hairiness and a study of this factor was planned. However, periods of stress from lack of moisture did not occur in 1945, but instead the abundant rainfall throughout the growing period provided almost continuously an excess of water.

Establistment of the fact that genetic and environmental factors control volume of aroma is of coordinate importance with determination of whether quality of aroma is at the same time also controllable. One might assume that quantity and quality of aroma are inseparably correlated, at least within certain intensity or volume ranges, and hence an analysis of hairiness might be expected to serve indirectly as a measure of quality of aroma. Support for this assumption stems from the fact that, to date, from spacing trials, it has been possible to detect differences in odor between the leaves of one and the same variety when the plants were grown differently spaced. The possibility that such differences in quality of aroma could exist may best be appreciated by recalling that the odors are constituted of a complex mixture of ethereal oils. According to Brüchner (1936), these ethereal oils are aldehydes, ketones, esters, and acids of various kinds and their cleavage products, all separable from tobacco leaves by steam distillation. During such distillation the resins, which are high molecular polymers, are cleaved to liberate various volatile oils. Even if one assumes that all varieties of tobacco elaborate the same complement of chemical entities, an unwarranted assumption but one that remains to be ascertained, it seems possible that variation in spacing, nutrition, moisture, light, or other factors might induce differences in the proportion of materials synthesized, and thereby cause the aromas to be different. Convincing proof of this remains wanting, however, because there are no suitable methods for measuring quality of aroma. Such lack constitutes a serious handicap in attempts to improve varieties of tobacco and in measuring responses to different environments. Attention might well be given, as a next step, to improvisation of methods to analyze quality of aroma.

SUMMARY

Studies involving hairiness of tobacco have been continued. The results show that hairiness can be increased by hybridization and/or selection. Additional evidence has been secured that hairiness is modified in response to spacing practices and in response to light. These findings indicate (1) that, to a degree, both the volume and quality of aroma are controllable; (2) that all varieties of oriental tobacco may not produce tobacco of largest yield and best quality if spaced alike; (3) that analysis of hairiness seems to provide a means of determining proper spacing and fertilizer practices.

DUKE UNIVERSITY
DURHAM, NORTH CAROLINA

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ON THE USE OF ARTIFICIAL HEAT IN THE PREPARATION OF HERBARIUM SPECIMENS

W. H. CAMP

The perennial discussion of "naturally dried" vs. "heat-dried" specimens has been recently revived by Professor Fernald (Rhodora **47**: 258–260. 1945); his arguments are reinforced by included comments by Bayard Long. From the combined texts the main objections to the drying of specimens by artificial heat seem to be (1) the loss of any glaucescence which might be present, (2) their greater likelihood to fracture and fragment, and (3) a more than implied tendency by users of the artificial method to hurry the material through the drying process and so fail to obtain specimens which are satisfactorily arranged on the sheet.

As a confirmed user of the "artificial" method I must bow to the accusation that specimens with just those unfortunate drawbacks *can* be so produced. However, it is possible either to avoid or overrule these objections to a large extent.

Regarding the first one—that of loss of glaucescence—there is but little that can be done about it. Having some slight experience with a group of plants (the Vacciniaceae) where the item of glaucescence is of considerable importance, it has been my experience that, no matter whether the "artificial" or "natural" method is used, I still cannot rely with surety on the character in the dried state since, in this group, the glaucescence is the result of an oil-air-emulsion and usually is easily lost by the mildest of abrasions either during collection or in press. It is obvious that the use of specimens over a period of time also tends to dim this character—at least in the blueberries—and so I have deemed it best to rely almost entirely on notes taken in the field. It would seem then that, for at least some groups, the objection raised by Professor Fernald that the drying of specimens by artificial heat does not permit him to make certain identifications might quite as well be critically directed at the field habits of collectors themselves as with their method of drying the plants.

As an example, I have close at hand a packet of specimens which I am checking—specimens for the most part made by well-known collectors. In making a selection from this packet care was taken only to ascertain that the specimens had been collected by those who were botanists (and for the greater part taxonomists) and therefore *ought* to know the problems confronting the systematist. On each of these sheets there is a ticket explaining in considerable detail exactly where the material was collected—data usually

so excellent that one could return to the exact locality and recollect the material if so desired. However, on not a single one of these is there the slightest indication by collector's notes whether the material was a tree or shrub (being of the genus *Vaccinium* one can only trust that they were shrubs); nor is there any note concerning the type of plant—i.e., whether solitary or in clumps (clon-forming). Naturally, with those omissions, one scarcely would expect that items such as the relative glaucescence of the upper and lower surface of the leaves or the glaucescence of the fruit would be recorded, but one might logically expect that at least some mention could have been made of the color of the flowers or mature fruit (all of which are of considerable importance in the systematics of this group). However, the greatest lack apparent on these tickets is that of height of plant. Of these specimens (and I repeat, they were taken more or less at random—the first dozen or so which came to hand in the parcel nearest me) only 1 records this item of plant height, an item often extremely useful in classification.

As Long notes in his personal communication as printed by Fernald, "Of course it [artificial drying] saves 'busy' men much labor but it produces a very unsatisfactory grade of specimens." Fernald then continues under his own momentum: "It is evident that we must remember the old saying, that 'haste makes waste.'" One can but be curious whether the collectors of these specimens (well known for their use of the "natural method") might not have been so "busy" changing blotters, running in and out between showers trying to dry them, and occupied with the other myriad of similar chores attendant to their favorite system of specimen preparation, that they had no time while in the field to jot down what might reasonably be thought of as a minimum of data concerning the habits and characters of the living plants. Possibly in their attempt to achieve "pretty" specimens they could not be bothered with one of the really basic elements of taxonomic study—that of a set of effective field notes. One wonders if instead of "haste makes waste" it might not be otherwise—a case of "borrowing from Peter to pay Paul"?

It would therefore seem that a method of handling specimens in the field which liberates the collector from the tedium of changing blotters ought to be welcomed, one giving him more time to study the material in the fresh state, sufficient at least to record adequate notes. So far as the objection that artificial drying destroys glaucescence is concerned, it might well be disregarded. It would seem that the character of glaucescence ought to be recorded along with such items as flower or fruit color, as well as the height and habit of the plant.

Now for the objection that artificial drying makes the plants brittle. It is a true and certainly valid objection if the material is not properly handled before being put on the heat. In his first paragraph Professor Fernald—and

quite rightly—points out the proper procedure. Except in emergency cases or with certain materials, the specimens should stay between blotters for a full 24 hours before being placed between the corrugates and on the heat. So far as I know no actual research has been done on this item, but there is no doubt that, generally, the results are much better if the "sweating" period is carefully attended to; the result is specimens which usually are quite as flexible and rarely more brittle than those naturally dried. It would seem that during the "sweating" process—and because of the exclusion of air in the press—there is a slightly modified form of anaerobic oxidation within the plant tissues so that instead of the more common oxidation of the carbohydrates at least slightly greater amounts than usual are changed to fatty compounds and that it is these substances which, slightly diffused through the tissues, lend a certain pliability to the completely dried specimen. While this statement is certainly in the realm of speculation the net result does indicate the advisability of the "sweating" process prior to drying by artificial heat.

Nevertheless, even after due care is taken with the sweating, there yet is danger that the heat becomes so great that it leaves the specimens brittle. Again, it is my opinion that excess heat drives off these fatty compounds by distillation and that herein lies the danger rather than in the use of "artificial" methods. When a press over the heat source is too hot for the hand it is too hot for the specimens. Certainly a "rule of thumb" but nonetheless effective.

The third objection—voiced by Mr. Long—is that "They [the specimens] get dried without even being examined again (while green and fresh) and, of course, there is no opportunity (if desire) to straighten leaves, draw flowers or fruit into view, or any of the other desirable "fixing" which results in good specimens." It is obvious that if the specimens are placed directly over the heat there would be no opportunity to arrange them. But one might ask: Just how often is it necessary to paw over a specimen before it is properly arranged? If the program suggested by Professor Fernald (and agreed with in completeness by me) were followed, it would seem that ample opportunity would be afforded for a preliminary arranging of the specimen as it was first placed in press and also for a final inspection and "fixing" after the "sweating" process is complete and just before being placed in position for drying. It is a rare specimen indeed which at the end of a 24-hour period of "sweating" is not sufficiently "tamed" that its parts will not lie in place when arranged for the final drying.

Having but recently returned from a trip into one of the moister parts of South America, I feel perhaps somewhat qualified to mention certain items relative to the problems of collecting under conditions which possibly would not be classified as the most ideal. I trust that this personal reference

will be pardoned, but the figures are at hand and the situation available from my notes and memory. It will suffice, therefore, to say that from the latter part of July to the first part of September, 1945, my two local Cholo helpers and I were in the Cordillera Oriental of Ecuador working from about 7,500 feet up to elevations of approximately 11,500 feet. At best the trails were poor; sometimes they were non-existent, in such instances necessitating the slow and laborious cutting of paths, often through dense thickets of *Chusquea* (the bamboo-grass so characteristic at these altitudes). It is a region where the annual precipitation may equal—or even exceed—200 inches; also, it was the height of the rainy season. Those who have worked at the higher elevations in the wetter parts of the Andes will understand the conditions under which we labored without further expansion of this topic. It might also be added that we were in a zone which, so far as I am aware, had never before been systematically collected.

During the 41 days we were in that particular zone only two or three were sufficiently sunny so that blotters could have been dried and on the great majority the sun did not show at all; most of the days it just rained. Yet in spite of this our little group returned from this particular area with more than 6,600 sheets of herbarium material in about 1,000 numbers. These figures are not given in a spirit of boasting, for it doubtless has been far exceeded by others in a like period. But of this I am quite certain: had we relied on the natural method of drying by means only of blotters, our haul from this area would have been numbered in the hundreds instead of thousands.

We used kerosene stoves as a heat source and there were times when, with materials jamming the presses, it was necessary to place certain specimens directly on the fire without the necessary preliminary "sweating" so as to keep the collections rolling and the drying process and stoves working at maximum efficiency. Much as I regret the fact that certain of these collections might not make quite so satisfactory specimens as one would like, other factors overbalanced that item. Considering the extent of our ignorance of the flora in that region, it would seem from the standpoint of the working taxonomist that a specimen, "*in herb.*" and with duplicates (even if slightly brittle and possibly with not all the leaves properly placed on the sheet) is worth considerably more than a whole mountainside of the same species as yet uncollected.

Another of the arguments against the use of artificial heat and the necessary corrugates in drying is that they tend to produce parallel ridges on the specimens. In certain cases and with particular materials, this is true. But I always have had the feeling that it is much better to work with a slightly corrugated specimen which was properly dried than one in which the flower parts had become heavily infested with fungi or eaten by larvae

already present in the material when collected—an ever-present danger in the much slower process where only a series of blotters is used, and a double danger under tropical conditions in the rainy season. It is also true—and especially so at certain seasons and while working with primarily woody forms such as one encounters in tropical regions (and a crying fault of many autumnal collections of woody materials in the temperate zone)—that too-long a wait in the "sweating" process accelerates the production of the abscission layer so that, although the parts have been quite prettily arranged, they promptly fall off, leaving only a bare stem and a hand full of loose leaves and flowers or fruit. The only remedy for such types under ordinary field conditions is to put them on the heat and dry them out as quickly as possible—and before the abscission layer has had time to fully form. Therefore where large "mushy" flowers are concerned as well as those in large and complicated clusters and so often subject to larval depredations while in the fresh and semi-fresh conditions, as well as those groups especially prone to dropping their leaves, it most certainly is not true that "haste makes waste." There are times when haste is the only method whereby material may be obtained in anything approaching a satisfactory condition. The desiccated start of a fungus culture, a larva killed by heat, or an incompletely formed abscission layer, are not feared by the collector; uncontrolled by prompt action, they result in nearly useless specimens.

In his introductory sentence Professor Fernald mentions the use of "corrugated pasteboard" thereby passing by what one might suppose would cause him even more alarm—the present vogue for the use of metal corrugates. Having used all methods—blotters only, corrugated pasteboard with double facing, single-faced paper corrugates as well as several styles of metal corrugates—I have come to the conclusion that, by and large, the metal corrugates lend themselves to the problem of extensive collecting better than any other.

In the first place—and I would make it clear that the following remarks apply primarily to "expedition collecting" in regions and at seasons where the humidity is high—the blotter method can be excluded on the following counts: (1) It consumes time which might better be spent both in the field and in the assembling of adequate notes; (2) there is too much danger of spoilage by fungi and minute larvae (the application of an alcohol-formaldehyde solution is, in my opinion, only an emergency measure at best); and (3) even if conditions were such that blotters could be used, the factor of bulk still would rule them out. Where supplies must be carried by plane, by canoe, by mule, or even at times on the backs of men, both bulk and weight are very considerable items and add materially to the expense of collecting.

As far as double-faced corrugated pasteboard is concerned it does have

certain advantages where one wishes to speed up the drying process to a considerable extent. But where the corrugates must be used repeatedly the openings tend to close up all too quickly and so the whole reason for using them is defeated. Unless the ducts are fully open, permitting a rapid desiccation, the specimens tend merely to "stew in their own juices" and so *do become brittle* after ultimate drying. I have long had the opinion that many of the criticisms leveled at the drying of specimens by the use of corrugates actually stemmed from this failure of the process rather than from the use of artificial heat. Besides the fault that the double-faced corrugates all too soon become worse than useless, they also are quite uneconomical of space and bulk too much in the baggage.

While the single-faced paper corrugates occupy much less space than the double-faced ones (because they can be "nested") and are therefore more to be desired, they also have the failing of ultimately breaking down and becoming useless. However, in the long run, I prefer them to the double-faced type. This is especially true if transportation is not too great an item, but only if a completely adequate supply can be carried along. One of the problems confronting the collector in regions where supplies are not readily available is that of material for packing the bundles of dried specimens. Although the single-faced corrugated pasteboard has a life-span which is not overly great, yet with careful use and a little planing it reaches the end of its usefulness in the drying press about as fast as one has need of reinforcing for the bundles; thus, having outlived its usefulness as a drier, it next becomes useful in wrapping and protecting the already dried specimens. For ordinary collecting one can expect to consume about 100 corrugates per 1,000 specimens; that is, a single-faced corrugate can be used about ten times. It is to be admitted that during the last half of its life it is not nearly so effective as when new. This also increases the time on the fire and therefore adds to the danger of overheating the specimens while still wet; it also increases the amount of fuel needed to complete the drying process, certainly an item which cannot be ignored.

This brings us to the metal corrugates. They have two great advantages. The first is that with any reasonable care their life-span is indefinite. The second is that although unit for unit they weigh considerably more than cardboard corrugates, the total weight of a set of metal ones needed for even a moderate trip is considerably less than that of cardboard ones necessary for a like amount of specimens. The problem of wrapping the dried material is still with the collector, but it has been my experience that a roll of heavy wrapping paper (preferably the type used by nurserymen to wrap plants—double-faced with a thin layer of tar between) serves quite as well as the ultimately flimsy corrugates and has the added advantage of being both waterproof and (because of the tar) insect-repellant. Furthermore, when

one uses metal corrugates, they can be forgotten while moving the scene of operations. One has enough to worry about while moving about, what with seeing that the food, the equipment, and specimens already collected are snug and dry. Accidents can and will happen: cases of equipment have been left out on docks in some port during the rainy season, a box can be dropped out of the canoe as it is being unloaded, a carrier can slip while crossing a stream and fall with his load, or a careless mule driver may not have taken sufficient care with his cargo cover during a long trek in the rain. With metal ones the collector never has the sorry experience of opening a packing case expecting to find corrugates, only to find a useless pulpy mass instead.

It is to be admitted that, because of their lower pliability, the metal corrugates tend less to follow the contours of the specimens than do the paper ones and so may cause some secondary corrugation of the specimen. But with a slight amount of practice the drying presses can be so packed that this item usually causes but little trouble. If one starts correctly in the beginning of the pressing process, laying the butts or thicker parts of the material in rotation in the different corners, this will carry right through to the drying press; and it is surprising how little trouble is encountered and how even the press will be.[1] It is true that in flimsy-textured materials a slight amount of residual corrugation of the specimen may occur. But it is just such materials which cause the greatest trouble under tropical conditions. Again, it should be pointed out that there are those who would rather work with a specimen intact but which has a few minor and scarcely visible corrugations on it than one which had become half-rotted and all but buried on a mat of fungal hyphae in the drying process.

In my own use of metal corrugates I have come to the conclusion that the most efficient order of packing in the drying press is as follows: corrugate—specimen in folded newspaper—blotter—specimen in folded newspaper—corrugate; etc. In the first part of the process over the heat the press may be so placed that the newspapers open downward; toward the end the presses should be reversed so that the crease in the paper is at the bottom, thereby making certain that no odd fragments (extra flowers included for dissection, etc.) can fall into the fire and so be lost or perhaps cause a slight

[1] In passing it might be noted that the same principle applies to the mounting of herbarium specimens. While the individual specimen may look better mounted in the "classical manner" as advocated in certain places—with the label at the lower right corner (where it ought to be) and the stem-butt at the lower left—a constant rotation of the position of the bulky parts of the specimen in the long run will keep the sheets more or less level on the herbarium shelves and so avoid the "cascades" of sheets and "camel-backed" covers which one sometimes encounters. It is obvious that if this is done in the mounting room there is chance that a few pigeon holes will cause some trouble, but the law of averages usually holds the specimens on an even keel. In certain woody groups the saving in herbarium space is as much as 15 per cent; in extreme cases it may be almost 40 per cent.

burst of flame which, under certain conditions, might cause a blaze. With particularly tender materials, perhaps some special specimen with an unusual flower cluster or possibly some item of extreme interest with the flower parts already dissected and laid open, the order in the press might be slightly different: corrugate—blotter—specimen in folded newspaper—blotter—corrugate.

Then there is perhaps necessary a word about the corrugates themselves. They may be made of "tin" (tin-plate), but the best of them tend to corrode and wear with use and so start rusting. Aluminum would be better; and it is likely that a little scouting among the newer of the light-weight alloys would reveal some excellent materials. A combination of lightness and tensile strength without brittleness would be ideal. So far as the size of the corrugations is concerned—and having used several types—it is my opinion that they should be about 1.5 cm. from crest to crest with a total depth of 0.5 cm. This may appear to be a little coarse to some workers, but it is my experience that if the corrugations are shallower the plant parts tend to squeeze into the "valleys" stopping up the ducts and so defeat the whole purpose of the set up. On the other hand if the distance between crests is cut to less than 1.5 cm. the surface of the edge in contact with the specimen necessarily will have to be too sharp and so tend to add to the creasing.

This problem of creasing when using corrugates of any kind—and especially with the metal ones—has been alluded to so often that I am moved to make several additional observations on their use. Custom and habit often influence our methods. Most of us began our plant pressing by using blotters, where we learned to "heave on the straps and squeeze out the water." And I have seen many a fellow collector stand on the press (sometimes even jumping up and down) while his assistant grunted over the fastenings. There is considerable sense to this procedure where blotters alone are used, for pressure does get rid of some of the water and, furthermore, an intimate contact between the plant and blotter speeds up the process of diffusion. Curiously enough, I have seen certain collectors use much the same technique when "trying out" the metal corrugates for the first time. It is not necessary; actually it is this unnecessary pressure which forces the specimen into the corrugations, not only slowing down the drying very considerably but also producing the ridging on the specimens bemoaned by so many. A firm contact between the specimen and press is all that is needed.

Naturally, it will be necessary from time to time to tighten the fastenings on the press—but that is also true of those specimens dried entirely with blotters. The trouble is that with the use of metal corrugates over even moderate heat the drying process goes on so rapidly that a collector who has not used them previously waits until the press is loose. By that time the specimens often have shriveled and already dried beyond the point where any-

thing can be done with them. After a tough day in the "bush" and with three or four hours more spent beside a dim kerosene lantern or flickering candle checking over and possibly amplifying field notes as well as arranging the specimens collected the previous day (and which already have gone through their 24-hour period of "sweating"), it is not always a particularly easy thing to wake up two or three times during the night and crawl out from between warm blankets to check the fires and see that the press fastenings are snug, but it is part of the job. During those nocturnal chores—done almost automatically after a while—one often can hear the sibilant patter of rain on the thatch. It rained all the day before—and the chances are very good that it will rain all the next day—just as it has for so many days in succession. But no matter. The collecting keeps on and (what is more important) one knows that the specimens are being dried on schedule. For the conscientious collector there is a peculiar brand of comfort in this knowledge as he crawls back into his blankets.

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THE EVALUATION OF TAXONOMIC CHARACTERS OF CULTIVATED BRASSICA WITH A KEY TO SPECIES AND VARIETIES—I. THE CHARACTERS[1]

VON GEE SUN

INTRODUCTION

A better classification of *Brassica* has long been needed. While much has been published on this genus, workers from the time of Engler and of Bailey to the present have been influenced by the demand of agricultural botanists for a satisfactory agricultural classification. The author believes that the resulting combination of botanical principles and agricultural convenience is responsible for much confusion.

The evaluation of morphological characters in conjunction with studies of genetics and cytology of interspecific hybrids has been used by the writer in making a classification based primarily on botanical principles.

It should be emphasized also that most quantitative characters have been overlooked by the taxonomist because of the difficulty of observation and a lack of standard methods for group comparison. It is easy to investigate a quantitative character by means of small sample measurements and analysis of variance. The writer applied this method to quantitative characters of different species of *Brassica* in order to evaluate them taxonomically. Because of the lack of detailed genetical studies of the genus, he has not arrived at a final conclusion on the entire taxonomic problem.

REVIEW OF LITERATURE

The more important of the older contributions to the classification of *Brassica* are those of Bailey (1922) and of Engler and Gilg (1924). Recently

[1] Contribution from the Department of Agronomy, College of Agriculture of the National University of Chekiang, where the author is Professor of Agronomy and Director of the Agricultural Experiment Station.

This paper was originally addressed to the Botanical Review, being forwarded by the Department of State. It was sent then to the editor of the Bulletin, and by him submitted for review and criticism to Dr. H. K. Hayes of the University of Minnesota. At the instance of the latter the paper was carefully read by Dr. T. M. Currence and Dr. A. E. Hutchins of the Department of Horticulture of the same institution, who made valuable suggestions and effected some modification and condensation. Certain additional changes were made by the editor; a few figures were omitted. Because of current conditions it was obviously impractical to communicate with the author in the usual way about his paper. The editor trusts that these emendations will prove acceptable to him.

Part II, containing a discussion and the key to species and varieties, with the list of literature cited, will appear in an early issue. Publication of the figures was assisted by the Lucien Marcus Underwood Memorial Fund.

Morinaga in a series of important papers (1929a,b,c, 1931, 1933, 1934) discussed the natural species-groups of *Brassica* in the light of cytological work and indicated the principles of a classification which should be acceptable to taxonomists.

Engler and Gilg divided the Cruciferae into two main groups, as follows:

A. Hairs unbranched or none; no glandular hairs.
B. Hairs all or in part branched, only seldom lacking; glandular hairs sometimes manifest.

Under A we find the Sinapeae, characterized as follows:

Sinapeae. Stigma strongly developed over the placenta, on a capitate or 2-lobed style.

This tribe is divided as follows:

b. Cotyledons arising at the curve of the embryo.
β. Mostly with lateral and median nectaries; fruit mostly a silique, seldom a silicle or a transversely jointed silique or indehiscent.
II. Style 2-lobed or suppressed.
Brassicinae. Cotyledons conduplicate; nectary present; silique sometimes transversely jointed.

Four genera, *Eruca*, *Sinapis*, *Brassica*, and *Raphanus*, were mentioned under this tribe. Five cultivated species exclusive of *Sinapis alba* were recognized in *Brassica*. These are: *B. nigra* Koch; *B. oleracea* var. *acephala* DC.; var. *gongyloides* L.; var. *gemmifera* DC.; var. *sabauda* L.; var. *capitata* L.; var. *botrytis* L.; *B. campestris* L. (= *B. rapa*) var. *annua* (summer oil seed type); var. *oleifera* (winter oil seed type); var. *rapifera* (turnip); *B. napus* L. var. *annua* (summer rape); var. *oleifera* (winter rape); var. *napobrassica;* and *B. juncea* Coss.

In the opinion of the writer the exclusion of *Sinapis alba* from *Brassica* should receive the careful attention of present workers. The classification of varieties in the *B. campestris* and *B. juncea* group also needs investigation.

Bailey (1922) described species and varieties of *Brassica* in great detail. He separated the genus by the following characters:

A. Species with fr. plainly dehiscent by 2 valves.
B. Fr. a narrow silique, manifestly longer than broad, the septum or partition usually flatwise of the pod and as broad as the valves.
C. Seeds in a single row or series lengthwise the pod in each compartment.
D. Stigma simple or essentially so, and nearly or quite capitate.
E. Plant glabrous, or if hirsute or pubescent then with simple hairs.
F. Fls. yellow or ochroleucous.
G. Length of fl. 1/4 in. or more; petals distinctly clawed; cotyledons conduplicate.

About 20 cultivated species were described; *Sinapis alba* was considered as a member of the genus. From an inspection of the available material, also

from Bailey's original description, it can be seen that though the above-mentioned 7 key characters hold true generally for most species of the genus, character E does not seem to be applicable to *Sinapis alba*.

Bailey recognized the following characters as important in the separation of species: glaucescence of plant, size and color of flower, habit of sepals (erect or spreading), distribution of flowers on the inflorescence at anthesis, shape and length of beak, and shape of leaves. Many of his subdivisions appear to be based on leaf characters.

Pearson (1928) was the first author to suggest classifying *Brassica* on the basis of the chromosome numbers. He recognized four classes in the genus, based upon determinations of chromosome numbers; owing to Karpechenko's wrong determination of the chromosome number of *B. napus*, Pearson made no satisfactory grouping of the genus.

Nagai and Sasaoga (1930), Karpechenko (1930), and Morinaga and Fukushima (1930) made exhaustive determinations of the chromosome numbers. Their results show that there are 7 groups of numbers in the genus, which may be listed as follows:

Chromosome number	Species examined
12	*B. alba* Rabh. (*Sinapis alba* L.)
8	*B. nigra* Koch (*Sinapis nigra* L.)
9	*B. arvensis* Rabh. (*Sinapis arvensis*)
	B. oleracea DC. (all known varieties)
10	*B. campestris* L. (all known varieties)
	B. chinensis L. (many varieties)
	B. pekinensis Rupr. (many varieties)
	B. narinosa Bailey
	B. nipposinica Bailey
	B. rapa L. (many varieties)
17	*B. carinata* Braun
18	*B. juncea* Coss. (many varieties)
19	*B. napus* L. (many varieties)

The above results throw some light on the grouping of the species, but relations between species with different numbers of chromosomes remain obscure.

Morinaga in his long series of cytological investigations (1929a,b,c, 1931, 1933, 1934) of the interspecific hybrids of *Brassica* showed that three fundamental chromosome sets were present. Species having haploid numbers of 8, 9, and 10 were considered as elementary species; others were considered as amphidiploid species. Each amphidiploid was said to be derived from the combination of two elementary species. As a result of Morinaga's work, the cultivated species of *Brassica* may be classified in the 6 groups shown in table 1.

In addition to Morinaga's results, U (1935) obtained even more decisive data, which confirm much of Morinaga's views. From the cross *B. campes-*

tris × *B. oleracea*, four F_1 plants were obtained: COF_1–1, intermediate, closely resembling *B. napus* in appearance, rather sterile, having 19 somatic chromosomes and producing $(0–8)^{I} \pm (19–3)^{II}$ at meiosis; COF_1–2, more fertile, with 28 chromosomes, producing $(0–5)^{III} \pm (9–4)^{II} \pm (10–5)^{II}$; COF_1–3, also more fertile, with 29 chromosomes, producing $10^{II} \pm 9^{I}$; and COF_1–4, almost fully fertile, with 38 chromosomes, producing 19^{II} at meiosis. COF_1–4 was considered to be an experimentally produced *B. napus*, being an amphidiploid with reduplicated chromosome sets of *B. campestris* and *B. oleracea* (aacc); while COF_1–2 and COF_1–2 were triploids with reduplicated sets of *B. oleracea* and *B. campestris* respectively (acc and aac), trivalent formation in COF_1–2 being due to a slight affinity between *B. oleracea* (c) and *B. campestris* (a). The results of the crosses *B. napus* × *B. oleracea* and *B. napus* × *B. campestris* support these conclusions, meiosis in the F_1 of

TABLE 1. *Genomic constitution of cultivated Brassica.*

Group	*n*	Genomic constitution	Species	Remarks
I	10	aa	*B. campestris* L. *B. rapa* L. *B. chinensis* L. *B. pekinensis* Rupr. *B. japonica* Sieb.	elementary species I
II	8	bb	*B. nigra* Koch	elementary species II
III	9	cc	*B. oleracea* L. *B. alboglabra* Bailey	elementary species III
IV	18	aabb	*B. juncea* Coss. *B. cernua* Hemsl.	amphidiploid species from I and II
V	19	aacc	*B. napus* L. *B. napella* Chaix	amphidiploid species from I and III
VI	17	bbcc	*B. carinata* Braun	amphidiploid species from II and III

the former resembling that in COF_1–2 and in the latter COF_1–3, as is to be expected, if the genom of *B. napus* is what has been indicated. The F_1's of the cross *B. carinata* × *B. oleracea*, according to U, were very sterile, closely resembled the female parent, had 26 chromosomes, gave $9^{II} + 8^{I}$ at meiosis; except $CaOF_1$–2, which was completely sterile, had 35 chromosomes, and produced $(9–5)^{III} + (0–4)^{II} + (8–12)^{I}$, having a reduplicated *oleracea* set. The F_1's from *B. carinata* × *B. nigra* again resembled *B. carinata* and were highly sterile; they produced $8^{II} + 9^{I}$. These results suggest that the genom of *B. carinata* is a combination of those of *B. nigra* (b) and *B. oleracea* (c), a conclusion which is partly confirmed by the observation of $(0–6)^{III} + (9–3)^{II} + (18–12)^{I}$ in the single, fairly fertile F_1 produced from the cross *B. napus* × *B. carinata*. From the cross *B. juncea* × *B. carinata*, intermediate, partially fertile F_1 plants with 35 chromosomes were obtained, showing at meiosis $(8–16)^{II} + (19–3)^{I}$. This, in conjunction with Morinaga's results, shows that the genom of *B. juncea* is aabb.

In general, Morinaga's and U's genomic hypothesis of *Brassica* seems well established. But the more interesting problem is the taxonomic relation of *Sinapis alba* to *Brassica*.

Sun (1942) following Bailey's system, with his own observations, has formulated a key to the species and varieties of *Brassica*, in which he treats the early maturing Chinese rape, "siao-yu-tsai," as a variety of *B. chinensis* L. and the late maturing Chinese rape, "da-yu-tsai," as a variety of *B. juncea* Coss.; two other varieties, *B. juncea* var. *linearifolia* and *B. juncea* var. *orthocarpa* were added. *B. pekinensis* Rupr. is treated as a variety of *B. chinensis*.

Tsen and Lee (1942) in a preliminary study of Chinese cultivated Brassicas, described 12 varieties under *B. juncea*, 4 under *B. chinensis*, and 3 under *B. pekinensis*. Some of these are probably synonymous, comparable with Sun's (1942) suggested names. Tsen and Lee indicate that *Sinapis* and *Brassica* should be combined.

Sun (1943a), in a study of hybrid vigor in *Brassica*, found none in the F_1 of *B. pekinensis* (Meitan variety) × *B. chinensis* var. *pandurata* Sun (Meitan siao-yu-tsai), which indicates little genetic difference between these two varieties. From an inspection of their morphological characters, it can be seen that gross difference between them is confined to the foliar organs. In foliage color, siao-yu-tsai is light green and *B. pekinensis* yellow or yellowish-green; both have winged petioles except that in siao-yu-tsai the lower part of the wing may be occasionally lobed or wanting. Radical leaves of *B. pekinensis* are orbicular or obovate in outline, with broad, flat, and white petioles; those of siao-yu-tsai are pandurate to obovate, with thin petioles. From these observations and the results of crossing, Sun suggests that *B. pekinensis* be treated as a variety under *B. chinensis*.

MATERIALS AND METHODS

When the College of Agriculture of the National University of Chekiang moved to Meitan in 1940, a number of varieties of "yu-tsai" and brassicaceous vegetable crops were introduced from various parts of South China for breeding. Morphological characters of these introductions and of local collections were examined; crosses were then made between different varieties and species in the spring of 1941. The available materials mostly belonged to the 10- and 18-chromosome species; a few to the 9-chromosome group; and only one, rutabaga, to the 19-chromosome group. Later, Professor Jin Zon Yu introduced the Japanese *B. napella* Chaix to Meitan, and the 8-, 12-, 17-, and other 19-chromosome species were furnished by Dr. H. W. Howard of Cambridge, England, in the latter part of 1942.

All materials were planted in the nursery garden in small plots, and their morphological characters recorded from seedlings to maturity. For

quantitative or size characters small random samples were taken from each plot and the important characters were measured and compared by analysis of variance.

The characters are as follows:

1. Hairiness of plant.
2. Size of pollen grains.
3. Stem characters.
4. Root characters.
5. Shape of leaves.
6. Glaucescence and color of plant.
7. Branching habit.
8. Type of inflorescence at anthesis.
9. Type of sepals at anthesis.
10. Size and shape of petals.
11. Color of petals.
12. Length and shape of silique.
13. Length and shape of beak.
14. Angle between pedicels and rachis.
15. Number of seeds per silique.
16. Color and size of seeds.

Among the available materials, two may be considered as mutants. One is "tson-tsai," named by Sun (1942) *B. juncea* var. *linearifolia*. (In Tsen and Lee's paper, *urophylla* may be a synonym of this.) A description of this variety and its taxonomic and cytologic relationships with other varieties may be found in Sun and Sze's paper (1943c).

The other mutant is white-flowered "piao-er-tsai," which may suggest a similarity to Tsen and Lee's *B. chinensis* var. *rosularis*, but differs in some points. The plant is annual, dwarf, the height 2–3 feet at anthesis, the leaves dark green, nearly black, glabrous, shining or glossy, not winged, with white or greenish-white, thick and broad petioles, the leaf-blade orbicular, entire, more or less wrinkled, with one or two small ear-like lobes on the petiole just below the blade (fig. 8). The radical leaves are generally spreading on the ground. The stem-leaves are sessile, entire, usually triangular, cordate-expanded and clasping. Inflorescences are short at anthesis, approximately 18–25 mm., with flowers clustered at the tip. The petals are white, though at the point of inflection of the claw a very light yellow color is evident; the petal is 10–12 mm. long, 7–9 mm. wide; the sepals are separate and the pedicels spreading; the silique is short, 18–24 mm. long, the mean 20.2 mm.; the beak is 4–6 mm. long. The seeds are small and reddish-brown. Natural fertility is low. Crosses were made between white-flowered piao-er-tsai and other varieties of *B. chinensis* in order to study some of its mutant characters.

Besides these new types, individuals were found in both the *chinensis* and *juncea* groups with white (very light yellow) petals. These were selfed and crossed with normal yellow-petaled plants to study their genetic origin.

OBSERVATION OF CHARACTERS

A source of much confusion in earlier work has been the occurrence in *Brassica* of simply inherited characters with large individual effects. By virtue of a difference in one or two such characters, plants have been confidently classified in different species. A genetic study of the genus, however, immediately reveals the deceptive nature of such differences and leads to the discovery of specific distinctions based on differences in the hereditary make-up as a whole rather than on differences in particular characters. In devising a satisfactory classification it is necessary to use only such characters as are indicative of fundamental differences in genetic constitution; the value of the more important characters for this purpose will now be discussed.

It has been pointed out that six chromosome numbers occur in the genus. Such differences are well known as a basis of classification, e.g., in *Triticum*, *Avena*, *Hordeum*, *Gossypium*, *Nicotiana*, and *Datura*.

1. Size of Pollen Grains. As a result of experiments in the last two years, the writer (1943a) has reported that *Brassica* may be divided into two groups according to size of pollen. The large-pollen group includes species with $n = 18$ and $n = 19$; its mean pollen length ranges from 41 to 47 μ and the mean product of length × width from 1179 to 1541 μ^2. The small-pollen group includes species with $n = 9$ and $n = 10$; its mean pollen length ranges from 33 to 40 μ and the mean product of length × width from 735 to 1080 μ^2. Judging from the general appearance of species within each group, the writer has pointed out that the 9-chromosome are quite different from the 10-chromosome species, and the 18-chromosome very different from the 19-chromosome species. Actually the 19-chromosome are rather closely related to the 9-chromosome species, and the 18-chromosome to the 10-chromosome. The pollen size, therefore, cannot be regarded as a principal taxonomic character and should be considered only as of secondary importance.

In the spring of 1943, examination of pollen size of the newly introduced species was undertaken by Mr. S. S. Koo (Instructor in Agronomy in this University). Species examined included *B. nigra*, *B. campestris*, *B. carinata*, *B. napus*, and *Sinapis alba* of Dr. Howard; *B. napella* of Professor Yu; and the local material *B. chinensis* var. *pandurata* and *B. juncea* var. *orthocarpa*. Twenty measurements were made for each species. The mean pollen length and width are shown in table 2. The differences necessary for significance were determined by analysis of variance.

It is evident that significant differences in size of pollen grains exist

among the species examined. According to the writer's previous observations (1943b) and the results shown in table 2, one can conclude that *Sinapis alba*, *B. juncea* var. *orthocarpa*, *B. napella*, and *B. napus*, should be classified as large-pollen species, and *B. nigra*, *B. campestris*, *B. carinata*, and *B. chinensis* var. *pandurata* included in the small-pollen group. The pollen length of *B. campestris* is significantly less than that of any other observed species; there are no significant differences among *B. nigra*, *B. chinensis* var. *pandurata*, and *B. carinata*. The pollen of *Sinapis alba* is significantly longer than that of other observed species; there are no significant differences among *B. juncea* var. *orthocarpa*, *B. napus*, and *B. napella*. It should be remembered that *Sinapis alba* has $n = 12$, and *B. carinata* $n = 17$. If the pollen size is closely related to the haploid chromosome number, then in this case

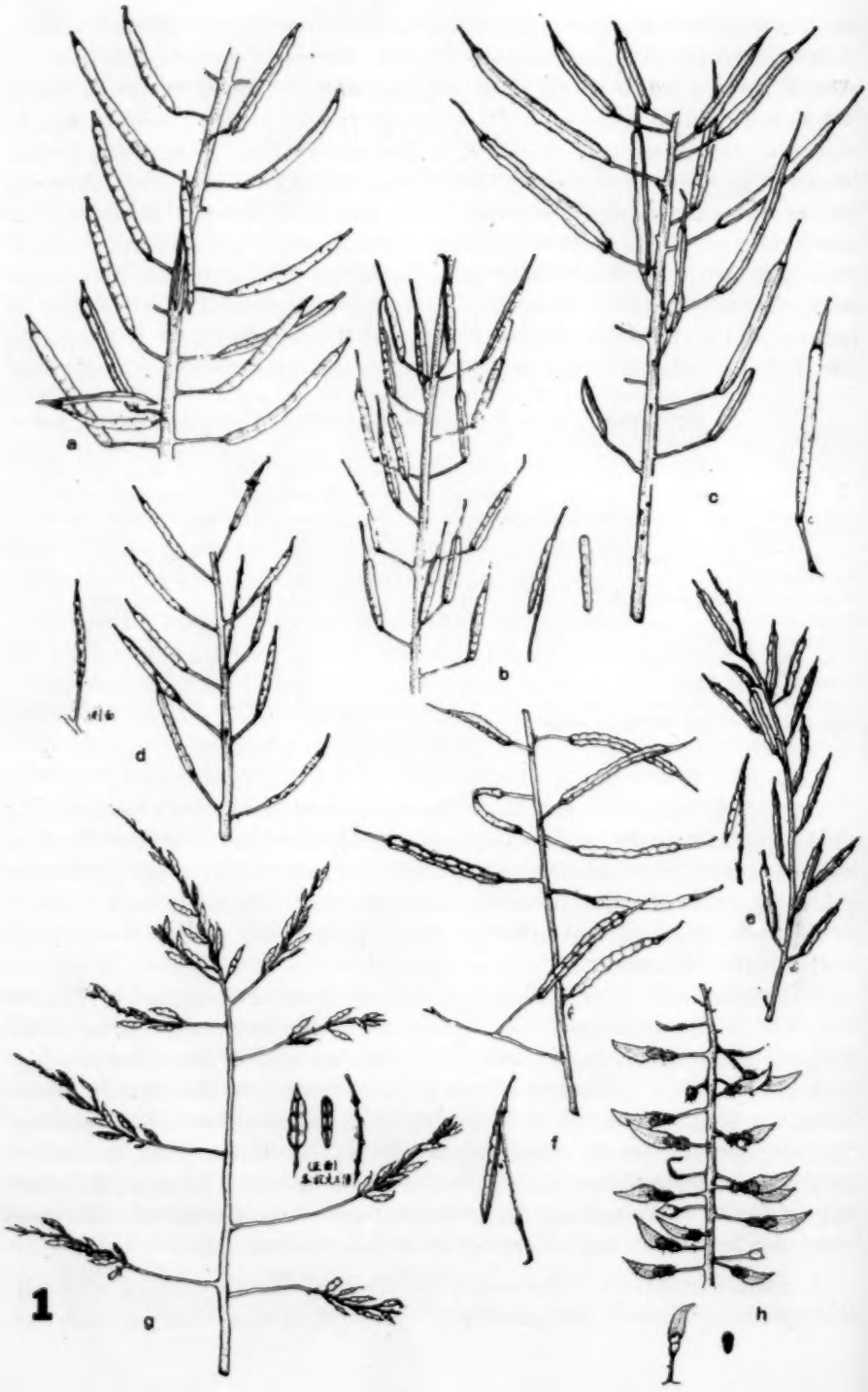
TABLE 2. *Mean length, mean width, and the product of length × width of pollen grains in different species of Brassica.*

Species	Length (μ)	Width (μ)	Length × width (μ²)
Sinapis alba	44.2	29.5	1304.3
B. nigra	35.0	26.1	914.1
B. campestris	32.4	23.8	772.7
B. chinensis var. *pandurata*	36.0	24.7	888.3
B. carinata	37.0	27.8	1030.9
B. juncea var. *orthocarpa*	39.5	29.8	1179.8
B. napelia	40.0	28.9	1157.3
B. napus	41.2	29.1	1200.4
Least significant differences at 5% point	1.4	1.0	.....

the relation is disproved. But if, on the other hand, we exclude *Sinapis alba* and consider the pollen of *B. carinata* as intermediate, the relation will prove to be real. Generally speaking, *Sinapis alba* has a lower chromosome number but larger pollen size than other species of *Brassica*. One might expect that it would prove to be of very different genetic origin and to have remarkable morphological characters.

2. Hairiness of Plant. This very distinct character was used by Engler and Gilg in the division of Cruciferae into two groups. According to all available material, the 9-, 19-, and 17-chromosome species are essentially glabrous; the 8-, 10-, and 18-chromosome species are more or less sparsely setose-hairy on young leaves and stems; on the ribs and veins of mature leaves much depends upon the variety examined. Moreover, the siliques of all species are glabrous, except that that of *Sinapis alba* has long setose hairs on the whole body of the fruit. This should be considered one of the significant differences between *Sinapis alba* and all species of *Brassica* proper (fig. 1).

3. Stem Characters. The writer has observed that the stems of all available species of *Brassica* are practically cylindric, having a very smooth sur-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face; but that of *Sinapis alba* is very rough, and has vertical furrows or ridges evenly distributed through its whole length (fig. 2). Since this character has not been found in other species, it may be considered as characteristic of *Sinapis alba*.

The stem of kohlrabi is thickened and bulb-like (fig. 3). In other characters it is rather closely related to *B. oleracea*. Kohlrabi should be placed in the 9-chromosome group and considered as a variety of this species, as Engler and Gilg did. As to the inheritance of the "bulb," the F_1 of the cross cabbage × kohlrabi is intermediate between the two parental races. In F_2 both forms reappear, but the majority of plants form a continuous series from

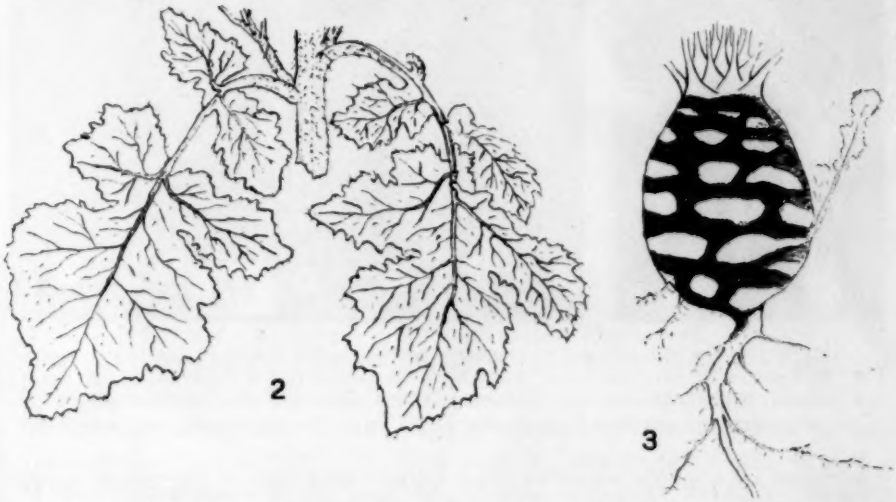


FIG. 2. Stem and leaves of *Sinapis alba*. FIG. 3. Thickened bulb-like stem of *B. oleracea* var. *gongylodes*.

one extreme to the other (Malinowski 1929, Pease 1926, 1927). Pease suggested three multiple genes, two of which, B1 and B2, are major while the third, B3, is minor or modifying. The triple recessive represents the ordinary stem of cabbage or kale. When both major genes are homozygous a kohlrabi bulb is formed. In a plant containing the two major genes it is not possible to detect by eye the presence of the minor gene. In the absence of the major genes, the minor converts "stalk" into "semi-bulb." On this hypothesis the ratio of the three classes, bulb : semi-bulb : stalk, should be 4 : 59 : 1; the actual figures obtained by Pease agree with this expectation.

The stem of *B. juncea* var. *tumida* is characterized by its enlarged rudi-

Explanation of figure 1

Siliques of various species of *Brassica* and of *Sinapis alba*. a, *B. oleracea* var. *acephala*; b, *B. campestris* var. *oleifera*; c, *B. chinensis* var. *pandurata*; d, *B. juncea* var. *gracilis*; e, *B. carinata*; f, *B. napus* var. *oleifera*; g, *B. nigra*; h, *Sinapis alba*.

mentary petioles and the shortened internodes of the lower part of the stem, a character which has not been found in other species (fig. 4). Because the plant differs in no other major character from varieties of *B. juncea,* it should be regarded as a variety of this species.

B. juncea var. *linearifolia* is characterized by a weak stem which is easily lodged under heavily manured or stormy conditions. In cross section the stem is rather irregular, not circular; it probably contains little lignified tissue. The writer has unpublished data to show that this weakness may be

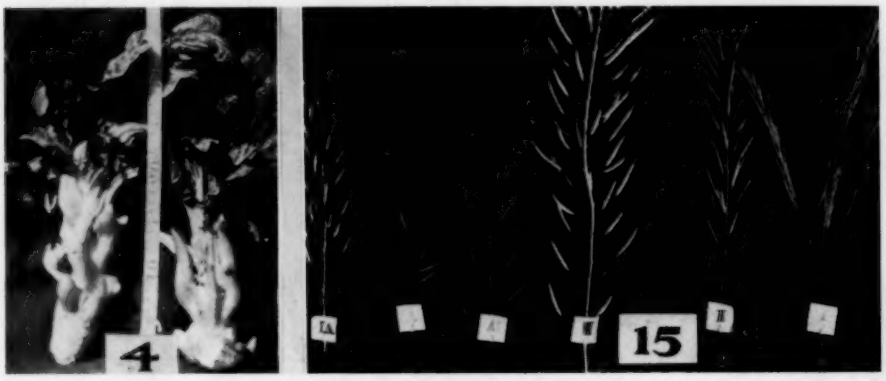


FIG. 4. Swollen and enlarged rudimentary petioles and nodes of *B. juncea* var. *tsatsai.* FIG. 15. Siliques of some species of *Brassica.* I, *B. juncea* var. *orthocarpa;* II, *B. juncea* var. *gracilis;* III, *B. chinensis* var. *pandurata;* IV, *B. campestris* var. *rapifera* (snowball); V, *B. campestris* var. *rapifera* (extra early purple top); VI, *B. chinensis* var. *albiflora.*

controlled by a single recessive gene. Other characters of the plant, except leaf-shape, are as in other varieties of *B. juncea.*

4. Root Characters. In certain species of *Brassica,* some roots are enlarged while others are not. Type of root has long been recognized as an important taxonomic character. Enlargement is only found in the 10-, 18-, and 19-chromosome species. This fact might lead one to postulate that the character has a single genetic origin. *B. rapa* may be considered as the original species of *Brassica* with enlarged storage root and rutabaga as derived from the combination of *B. oleracea* × *B. rapa* through chromosome doubling. Similarly, storage-rooted mustard (*B. juncea* var. *megarrhiza*) may be derived from the combination of *B. nigra* × *B. rapa.* However, the hypothesis is not supported by actual data. Kajanus' (1917) genetic studies and Morinaga's cytologic investigations should be considered as good examples for further study.

Color variation of the root of the tuberous-rooted species and varieties is very wide. The main coloring of the interior parts (the "flesh color"), both of turnip (*B. rapa*) and swede or rutabaga (*B. napus* var. *napobrassica*), is

either white or yellow. The yellow color is not due to a pigment in solution, but is borne in plastids. When yellow- and white-rooted plants are crossed, irrespective of which is the mother plant, the F_1 hybrids are all white-fleshed. If these are selfed the F_2 generation segregates 3 white to 1 yellow. The color inheritance in swedes is slightly more complex, the genes being duplicated. Hallqvist (1915), Kajanus (1913), and Davey (1931), working independently, have found certain white-fleshed varieties to contain both genes breeding true for the white color. When a white-fleshed plant of this nature is crossed with a yellow-fleshed swede, the F_1 is all white-fleshed. If these F_1 plants are selfed, the F_2 generation segregates 15 white to 1 yellow. In swede × turnip crosses, Kajanus found (1917) that the gene for white in turnip masks the yellow of the swede, while the white swede genes are dominant over the yellow of the turnip. In other words, the hereditary factors governing flesh color in both species are very similar, though more complex in the swede.

Swede strains are commonly grouped according to skin color as "purple top," "bronze top," and "green top." Kajanus (1912) suggested two genes governing them: P_1 giving red-green and dominant to green, and P_2 giving red and dominant to both red-green and green. Later (1913), however, he discarded P_1 because of the irregularity with which color appeared, and considered red-green and green to be fluctuating characters. Davey (1932), after re-examining the anthocyanin color inheritance in swedes, redefined Kajanus factor P_2 as N_1, which produced self-red or self-purple on the surfaces between leaf-scars of the "neck," and, with less certainty, strong vinous mauve on the "top." Another gene, N_2, was found, similar in action to but not identical with N_1. Complete absence of linkage was found between factors N_1 and N_2, and between these and the genes M_1 and M_2 which govern flesh color. Kajanus has shown that the genes governing flesh color in turnip and swede are probably the same. These facts and the frequent occurrence of duplicate factors in swedes may be considered as genetic evidence in favor of Morinaga's cytological viewpoint.

As to the shape of storage organs, Kajanus (1913) assumes that two multiple factors L_1 and L_2 are responsible for the length of the turnip "roots." The root-shapes produced by the different combinations of these genes are as follows:

Combination of genes	Number of genes	Shape of root
$L_1L_1\ L_2L_2$	4	long
$L_1L_1\ L_2l_2$	3	rather long
$L_1l_1\ L_2L_2$	3	rather long
$L_1L_1\ l_2l_2$	2	elongated
$l_1l_1\ L_2L_2$	2	elongated
$L_1l_1\ L_2l_2$	2	elongated
$L_1l_1\ l_2l_2$	1	rather short
$l_1l_1\ L_2l_2$	1	rather short
$l_1l_1\ l_2l_2$	0	short

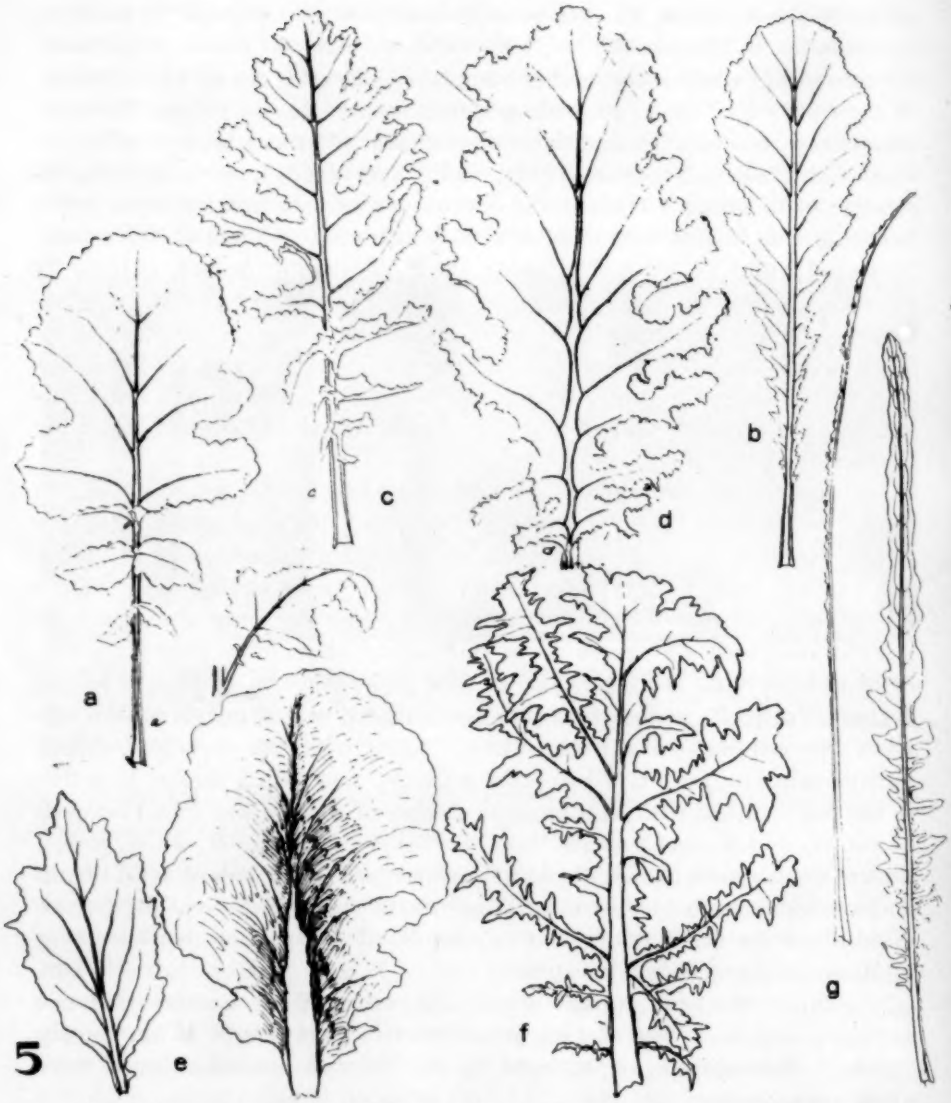


FIG. 5. Leaf-shapes of different varieties of *B. juncea*. a, var. *gracilis;* b, var. *oblanceolata;* c, var. *megarrhiza;* d, var. *tsatsai;* e, var. *rugosa;* f, var. *multisecta;* g, var. *linearifolia.*

5. Shape of Foliar Organs. The leaf shape of *Brassica* is quite variable even within a single species. For example, *B. juncea* var. *gracilis* has long-petioled radical leaves, the blades obovate to oblong-ovate, with small lobes gradually diminished toward the base; *B. juncea* var. *oblanceolata* has ob-

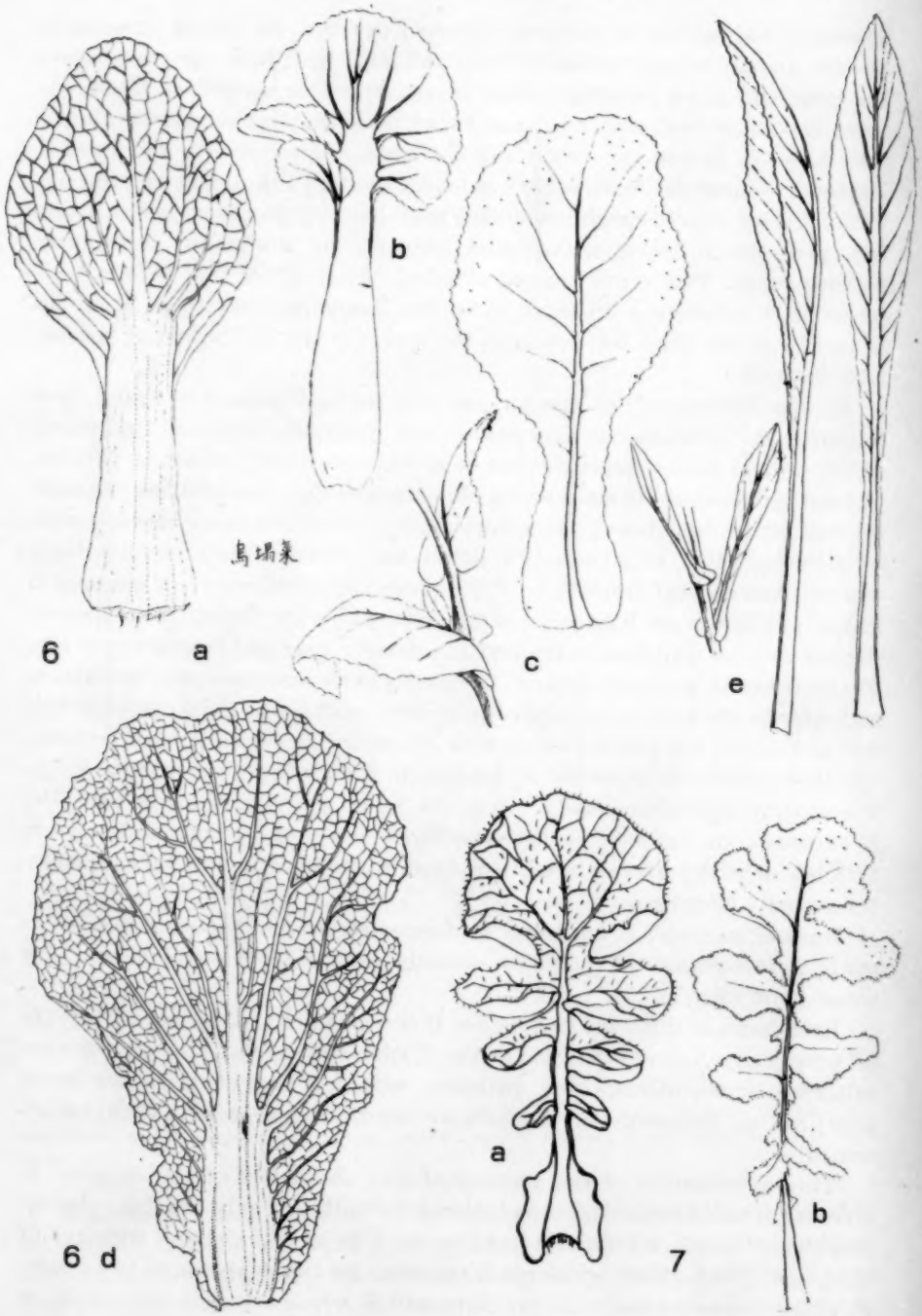
lanceolate radical leaves and weak grooved petioles, the blades irregularly incised, sharply serrate toward the base and not lobed; *B. juncea* var. *rugosa* has large and quick-growing radical leaves 30 cm. or sometimes 60–90 cm. long, obovate or oval, and stout and broad petioles, the blades extending to their base; *B. juncea* var. *crispifolia* has large crisped, curled, and fringed leaves; *B. juncea* var. *multisecta* has leaves multifid into linear or even filiform lobes; *B. juncea* var. *linearifolia* has all leaves linear, stem-leaves bladeless, and radical leaves with blades very narrow above but irregularly notched below. The writer has unpublished data to show that certain leaf-forms of *B. juncea* are inherited as simple Mendelian characters. It would be unwise to use these leaf-forms as the basis for the distinction of species. (See figure 5.)

In the 10-chromosome species also diverse leaf-forms are found. For example, *B. chinensis* var. *communis* has glabrous, rounded, undivided, entire radical leaves, tapering into long but unwinged, whitened petioles, and auriculate-clasping stem-leaves; *B. chinensis* var. *rosularis* has the radical leaf-blades broad-ovate or suborbicular, entire, distinctly marked with a number of veins, with thickened, broad, and greenish-white petioles, these scarcely bearing leaf-fragments; *B. chinensis* var. *pandurata* has the radical leaves pandurate or fiddle-shaped to oblong-obovate, tapering to narrow slender petioles which are margined and usually bear leaf-fragments or ear-like lobes below, unable to support the blades in an erect position; leaf-blades and midribs are more or less sparsely covered with setose hairs; *B. chinensis* var. *pekinensis* has radical leaves with characteristic broad-winged petioles, and its heart-leaves are crinkled, tending to form a head under suitable environmental conditions; there are a few setose hairs on the ribs beneath; *B. chinensis* var. *angustifolia* has stem-leaves non-clasping, long and narrow, petiolate or with a narrow base; its radical leaves are long and narrow, sometimes curly. (See figure 6.)

Radical leaves of *B. rapa* and *B. campestris* are long-obovate to oblong-ovate, lyrate-pinnatifid, petiolate, densely covered above and below with setose hairs (fig. 7).

Leaf-forms of different varieties of *B. oleracea* are also variable. They are all practically glabrous. Radical leaves of vars. *acephala* and *gongyloides* are relatively small, oblong-ovate, petiolate, with leaf-fragments on the lower part; radical leaves of var. *capitata* are sessile, large, mostly thick, broad-orbicular.

The investigation of the genetics of leaf characters of the races of *B. oleracea* as well as other races has proved difficult. Not only are these characters elusive of exact definition but also the type of leaf changes with age of the plant. Pease (1926) gives much evidence for the existence of two genes: *P*, which causes the leaf to be petiolate, and *E*, which causes it to be entire as


b
6 a
c
e
6 d
a
7
b

against lyrate. He suggests for cabbage the formula *ppEE*, and for kale and kohlrabi *PPee*. Brussels sprouts contain *PPEE*. The rare type of foliage "sessile lyrate" is presumably *ppee*.

The leaves of kohlrabi are narrower than those of cabbage. Pease reports for crosses of these two that when the F_2 plants with leaves about as narrow as the parent kohlrabi are picked out, they are found to form a quarter of the total number. He concludes on the basis of F_2 and F_3 data that one principal gene, *W*, is involved in this character difference.

Pease investigated a monstrosity of the leaf in which outgrowths developed from the ribs, running at right angles to the surface of the leaf. This anomalous growth is usually of a leafy nature, but may become stalky and even bear flowers and set seeds. This character, called "asparagodes," behaves as a simple dominant.

Another leaf character is worth noting, the curly foliage of curly kale, which seems to be determined by several multiple factors (Malinowski 1929, Pease 1926). The leaves of kale are well curled, those of cabbage flat or at most a little wavy. Hybrids are intermediate. F_2 segregation yields a continuous though asymmetric variation between the parental types.

In ordinary cabbage, the leaves of the terminal shoot are closely folded, forming the familiar dense head or heart. In Brussels sprouts, the same sort of deformity occurs, not in the terminal shoot but in the laterals. The two forms of hearting are determined by independent Mendelian factors and in the commonly cultivated types both forms do not appear on the same plant. The F_1 from cabbage × kale, × kohlrabi, or × any non-hearting *B. oleracea* other than Brussels sprouts is a plant with slight indications of hearting. The leaves of the rosette are curved inwards, but do not form a closed head. In the F_2 both parental forms appear, but the majority of the plants form a continuous range from one extreme to the other (Malinowski 1929, Kristofferson 1924, Pease 1926). Malinowski suggested multiple genes responsible for the hearts, determining the difference in degree of folding of leaves. His experiments indicate a possibility of 3 multiple genes. Pease gave evidence for a 2-gene system.

Kristofferson, who has made crosses between cabbage and Brussels sprouts, is inclined to believe that the cause of the development of heads in the leaf axils is not of a simple monohybrid type. The F_1 resembles Brussels sprouts, having well developed "buttons" in the leaf axils. At the top of the stem a large, rather compact head is formed. The development of buttons in the axils varies continuously in the F_2. In some plants these buttons are as

Explanation of figures 6 and 7

FIG. 6. Leaf-shapes of different varieties of *B. chinensis*. a, var. *rosularis;* b, var. *albiflora;* c, var. *pandurata;* d, var. *pekinensis;* e, var. *angustifolia.* FIG. 7. Leaf-shapes of (a) *B. campestris* var. *oleifera;* and (b) *B. campestris* var. *rapifera.*

well developed as in Brussels sprouts; in others they have the ordinary loose structure of kale.

Stem-leaves of *B. napus* are oblong-lanceolate, sometimes toothed and notched; the radical leaves are oblong-ovate (fig. 9).

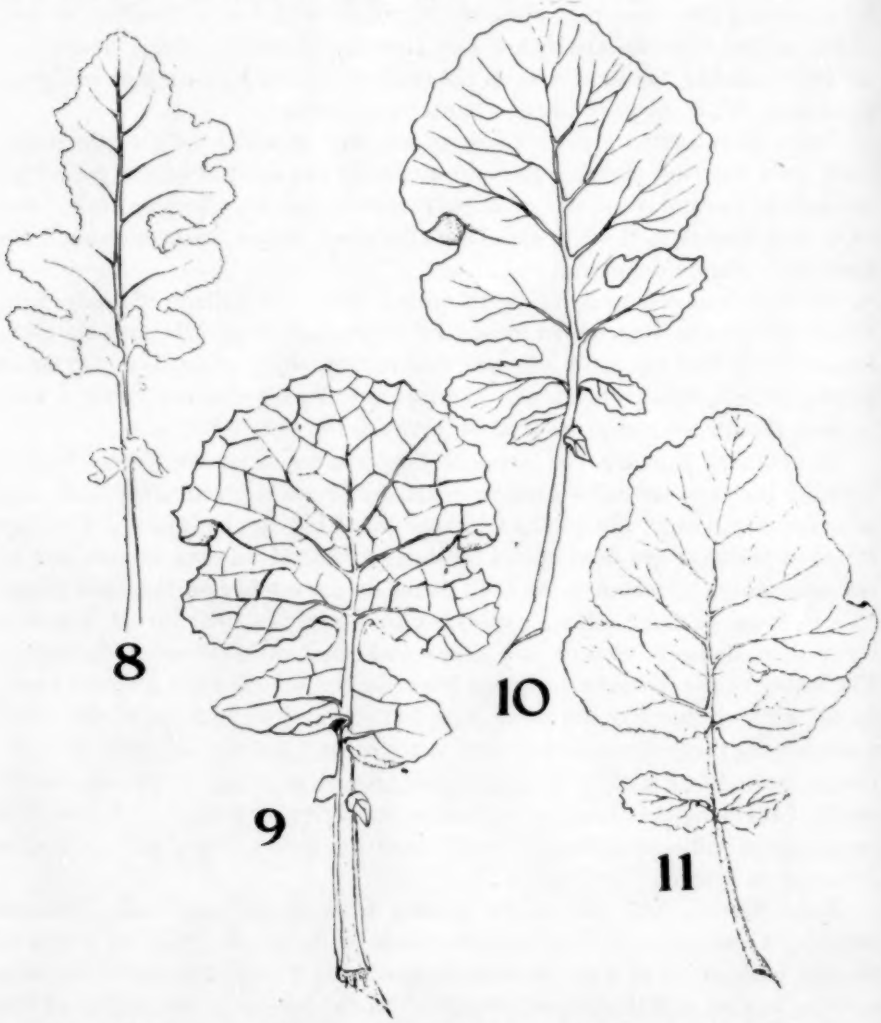


FIG. 8. Leaf-shapes of *B. oleracea* var. *gonglyodes*. FIG. 9. Leaf-shape of *B. napus*. FIG. 10. Leaf-shape of *B. carinata*. FIG. 11. Leaf-shape of *B. nigra*.

The basal leaves of *B. carinata* are shining, with large oval lobes 3–5 inches long, shallowly sinuate-dentate, with small lobes at the base and sometimes fragments on the long petiole; these leaves pass gradually into narrow upper cauline petiolate or narrow-based variously dentate floral leaves or bracts (fig. 10).

FIG. 12. Types of inflorescence of different species of *Brassica* and of *Sinapis alba*. a, *B. carinata*; b, *B. oleracea* var. *acephala*; c, *B. nigra*; d, *B. juncea* var. *gracilis*; e, *B. campestris* var. *oleifera*; f, *B. napus* var. *oleifera*; g, *Sinapis alba*.

Leaves of *B. nigra* are densely covered with hispid hairs, the radical not greatly developed, pinnatifid or lobed, the terminal lobe very large, the margins dentate or notched, long-petiolate as are the stem-leaves (fig. 11).

The leaves of *Sinapis alba* are oval, ovate, or obovate, divided deeply—even to the midrib—into 1–3 pairs of notched or angled lobes; the stem-leaves are long-petiolate, sparsely covered with setose hairs.

6. Glaucescence and Color of Plant. Bailey divided all species of *Brassica* into two main groups based upon glaucescence. All 9-chromosome and 19-chromosome species are glaucous-blue or blue-green, sometimes glaucous-red in horticultural varieties. It has been noted in the 10-chromosome species that glaucescence is found in *B. campestris* and *B. chinensis* var. *rosularis*, the others being essentially not glaucous. In Bailey's key to the species, *B. napiformis* was placed in the 9- and 19-chromosome section because of its glaucescence. However, by examination of other important characters such as those of flower and fruit, it should undoubtedly be placed in the 18-chromosome group.

According to the writer's observation, *B. carinata* is practically not glaucous but rather prominently glossy or shining.

As to the anthocyanin pigmentation of the foliage, red and purple have often been found in different species and varieties. For example, *B. chinensis* var. *purpurea* may be considered as the typical purple variety in the 10-chromosome group. The purple pigment is distributed practically throughout the whole plant except the petals. Purple mustard also has been found in Tsun-Yee, Kweichow, China; it belongs to *B. juncea*. The distribution of purple pigment can be identified as of three types. In the first the pigment is confined to the leaf-blade, while the stem and petiole or midrib are essentially green; in the second type purple is distributed practically throughout the plant except the petals; in the third purple is confined to the leaf-venation, and is not easy to detect without close observation. The mode of inheritance of color remains obscure. Genic analysis of the anthocyanin pigment formation of both 10- and 18-chromosome species has just been undertaken by the writer and Mr. C. S. Chu in the College of Agriculture of the National University of Chekiang.

Color variation in the foliage of 9-chromosome species is also wide. Results of genetic studies on color inheritance of the cabbage races are summarized in the following paragraphs.

Kristofferson (1924) reported extensive investigations on light red color of the midvein in cabbage and in Brussels sprouts. Crosses were made with broccoli, which was green in these parts. In the F_1 the midvein was light red; in F_2 the ratio was 3 light red : 1 green midvein. He designated the gene for light red as *B;* broccoli has *b*. A cross between light-red-midveined cabbage and a similar type in Brussels sprouts produced only light red in F_1 and F_2,

showing that the two factors were the same. This light red type was later referred to by Kwan (1934) as "sun-red." When kale, which has a green midvein, was crossed with this light red type, the F_1 had a dark red-violet midvein. The F_2 plants segregated into dark red-violet, light red, and green in a ratio approximating 9:3:4. This would indicate complementary genes. He assumed a factor *A* in kale which interacted with a factor *C* in cabbage or Brussels sprouts to produce this dark red-violet vein color; kale is *Ac* and cabbage or Brussels sprouts is *aC*. In F_2 there was a deficiency of the light red type carrying *B*, and a proportional excess of the green *b* type. This deviation, he suggested, might be due to linkage of *B* with either *A* or *C*. Since the crosses of broccoli with cabbage and with Brussels sprouts did not give dark red-violet midveins, broccoli must be *a*.

In further studies, Kristofferson (1924) found complete dominance of dark red leaf in the cross of green-leaved light-red-midveined cabbage with a dark-red-leaved type. In the F_2 there were approximately 3 dark-red-leaved plants to 1 green. This was also true in crosses of dark-red-leaved cabbage by kale, by Brussels sprouts, and by broccoli. He suggested the gene *D* for the dark coloration of red cabbage. But in the cross of kale with green-leaved light-red-veined cabbage or with Brussels sprouts, the leaf-color of the F_1 was dark red-violet. The F_2 ratio could not be explained by a simple hypothesis, since the variation was continuous. In the cross between red cabbage and tall kale, the F_2 ratio of intermediate and green to dark red was approximately 3:1. In the light red cabbage, he assumed that there was a gene *E* for extension of dark color when *A* and *C* were both present. From these results he formulated the most probable genetic constitution of the various types as follows:

Cabbage	dd	aa	BB	CC	EE
Red cabbage	DD	AA	bb	cc	ee
Brussels sprouts	dd	aa	BB	CC	EE
Kale	dd	AA	bb	cc	ee
Broccoli	dd	aa	bb	CC	EE

Pease (1927) assumed that in the purple kohlrabi two genes for pigment were present. His hypothesis is supported by the cross of purple kohlrabi × green savoy cabbage. Purple F_1 plants were obtained, giving a ratio of 9:7 in F_2. In crosses of purple F_1 plants with green cabbage the green behaves as a simple recessive to purple. Green cabbage, therefore, probably contains one of the complementary color genes present in purple kohlrabi.

About 1926, Dr. C. H. Myers of Cornell University found among the progeny of a selfed plant of the variety "Danish round red" a new color type which he named "magenta." Magruder (1930) obtained purple plants in the F_1 of a cross between sun-red and magenta. The F_2 contained 9 purple: 3 magenta: 3 sun-red: 1 green. The assumption of two genes explains

these results. The gene *M* is designated as responsible for the production of magenta and *S* for the production of sun-red. The purple type is *MS*, the green *ms*.

Kwan (1934) stated that a cross of deep purple × sun-red cabbage gave an F_2 ratio of 15 purple : 1 sun-red. The F_3 and intercross tests show that the assumption of two duplicate genes, R_1 and R_2, for purple will explain the results. The genes are shown to be cumulative in effect. From the cross deep purple × green a ratio of 9 purple : 3 sun-red : 4 green resulted. The F_3 fits the assumption that two genes are involved: *G*, a basic factor for pigment, which with *A* gives purple and with *h* gives sun-red.

7. Branching Habit. It has been noted by Bailey that *B. rapa* does not branch near the base, whereas *B. juncea* and *B. chinensis* do. According to the writer's observation, the variation in branching habit is very wide. *B. nigra* may be noted as an extremely high-branched species. The lowest branches of the main stem are not necessarily all low in *B. juncea* and *B. chinensis*. *B. juncea* var. *oblanceolata*, however, is an extremely low-branched variety of that species. It develops as many as 7–10 branches within 10 cm. of the ground. Certain other forms, such as *B. juncea* vars. *gracilis* and *orthocarpa*, practically never send out branches up to 90 cm. above the ground. Some varieties of *B. chinensis* branch very low and some rather high; but the highest-branching varieties never reach the height of some varieties of *B. juncea*.

B. oleracea, *B. napus*, and *B. carinata*, as far as the available material shows, all branch low.

In 1941, random samples of 50 plants in each of *B. chinensis* var. *pandurata* and *B. juncea* vars. *gracilis* and *orthocarpa* were measured for their plant height and the height of the lowest branching node. The results are shown in table 3. Significant differences exist among varieties in both plant height and height of the lowest branch.

TABLE 3. *Mean plant height and the lowest branching height in 3 varieties of yu-tsai (Chinese rape).*

Variety	Mean plant height	Mean branching height
B. chinensis var. *pandurata*	104.9	15.9
B. juncea var. *gracilis*	168.6	53.4
B. juncea var. *orthocarpa*	195.4	96.1
Significant difference at 5% point	10.8	9.1

Though the mode of inheritance of plant height and height of branching of different species is still unknown, it is certain that the importance of these characters in taxonomic studies should not be overlooked.

8. Type of Inflorescence at Anthesis. Bailey recognized this character as important in the separation of *B. oleracea* from other species. He described the inflorescence of *B. oleracea* as elongate and open at anthesis, 10–25 cm. long, while that of *B. napus* was short, the flowers clustered at the top and the blooming part usually 6 cm. or less in length. According to the writer's observation, this distinction is well marked. In general, the inflorescence of all varieties of *B. chinensis*, *B. juncea*, and *B. napus* is rather short at anthesis, the unopened flower-buds corymbosely clustered at the top, never elongate, and the part bearing opened flowers also short. The inflorescence of

TABLE 4. *Mean length of the blooming part of the inflorescence of 21 varieties of Brassica (1941).*

Species & variety	Common name	Mean length of blooming part
B. oleracea var. *capitata*	Common cabbage	11.9
B. oleracea var. *acephala*	Yellow-flowered kale	8.3
B. juncea var. *tumida*	Ling-chiao-tsai	7.0
B. chinensis var. *angustifolia*	Kweilin hwa-tsai (1)	6.7
B. juncea var. *rugosa*	Nanfeng chieh-tsai	6.2
B. juncea var. *gracilis*	Meitan da-yu-tsai	5.9
B. chinensis var. *pandurata*	Meitan siao-yu-tsai	5.6
B. chinensis var. *angustifolia*	Kweilin hwa-tsai (2)	4.8
B. napus var. *napobrassica*	Rutabaga	4.7
B. chinensis var. *communis*	Kasin green-petioled	3.5
B. chinensis var. *pekinensis*	Meitan hwang-ya-tsai (1)	3.3
B. chinensis var. *pandurata*	Shian-tan yu-tsai	3.3
B. oleracea var. *alboglabra*	White-flowered kale	3.2
B. chinensis var. *pekinensis*	Meitan hwang-ya-tsai (2)	3.1
B. oleracea var. *gongyloides*	Red kohlrabi	2.7
B. chinensis var. *communis*	Kiangmen pe-tsai	2.6
B. chinensis var. *albiflora*	Pe-hwa-piao-er-tsai	2.2
B. chinensis var. *communis*	Ishan pe-tsai	2.0
B. juncea var. *oblanceolata*	Shealiehung chieh-tsai	1.9
B. juncea var. *megarrhiza*	Pe-pa-yeh da-tou-tsai	1.7
B. chinensis var. *communis*	Kwangsi long-petioled	1.7
Significant difference at 5% point		1.15

B. carinata is extremely elongate, i.e., opened flowers and unopened buds on the rachis are very widely separated. Since this is typical of *B. oleracea*, these two should be placed in the same group as far as this character is concerned.

It should be noted that environmental conditions play a part in fluctuation of this character. Measurements of the length of the blooming part made on different days will vary greatly. When the air temperature is high and the relative humidity is low, the flowering process tends to be rapid, hastening the early fall of the petals; measurements taken under such conditions will be short. But if the air temperature is low and the humidity is high, flowering tends to be delayed and the petals persist longer on the flower. Measurements made at such times will be longer.

In the spring of 1941, random samples of 10 measurements on each of 21 specimens were made on successive days. Comparisons of the mean length of the blooming part for all varieties are shown in table 4. Analysis of variance between and within varietal classes for the 210 measurements was calculated. It is clear that variation in length of the blooming part among varieties and species is highly significant.

From table 4 it is evident that according to the type of inflorescence, *Brassica* may generally be divided into two groups, as pointed out by Bailey. One is the long loose type which includes certain varieties of *B. oleracea* and *B. carinata;* the other is the short compact type which includes some varieties of *B. oleracea* and all varieties of *B. juncea, B. chinensis,* and *B. napus.* Since variation of the two types is essentially continuous, one can hardly draw an accurate borderline between the groups. As far as present data are concerned, one may consider mean lengths of inflorescence above 8 cm. and below 7 cm. as the long loose and short compact types respectively. This is an arbitrary standard and may need modification.

9. Type of Sepals at Anthesis. Bailey recognized this character as important in the classification of species. In his key to the species, he distinguished two groups: under A are species whose sepals are mostly firmly erect and not spreading, such as *B. oleracea, B. napus,* and *B. napiformis;* under AA are those whose sepals are separate or spreading, such as *B. campestris, B. rapa, B. juncea, B. pekinensis, B. chinensis, B. nigra,* and *B.* (*Sinapis*) *alba.*

According to the writer's observation, three types of sepals may be found in *Brassica.* First is the firmly erect type (fig. 13, a) which includes most varieties of *B. oleracea,* such as common cabbage and kohlrabi; second is the separate type, with an angle formed between the sepals and the central axis of the flower of approximately 30–45°, which includes *B. carinata, B. napus, B. napobrassica, B. napiformis, B. campestris,* and most varieties of *B. chinensis;* third is the wide-spreading type, with sepals at anthesis perpendicular to the central axis (fig. 13, c), which includes *B. nigra, Sinapis alba,* and almost all varieties of *B. juncea.* Observation of these types must be made at a time when the flowers are fully open.

10. Size and Shape of Petals. Size and shape of petals should be considered as important taxonomic characters of *Brassica.* Bailey divided the species into two groups by length of petals. One is the long-petal group, the petals ranging from 15 to 25 mm. long, which includes all varieties of *B. oleracea.* The other is the short-petal group, the petals being 15 mm. or less in length, which includes *B. napus* and *B. napobrassica;* but varieties of *B. chinensis, B. campestris,* and *B. juncea* are said to have petals only from 10 to 12 mm. long. Data have been obtained by the writer and his coworkers to

show variation in length and width of the petals. Ten random measurements of the length and width in each of 22 specimens and 20 measurements in each of 8 specimens were made in 1941 and 1943 respectively. In 1944, 10 random measurements in each of 13 specimens were made. Comparisons of variety and species means are shown in tables 5, 6, and 7.

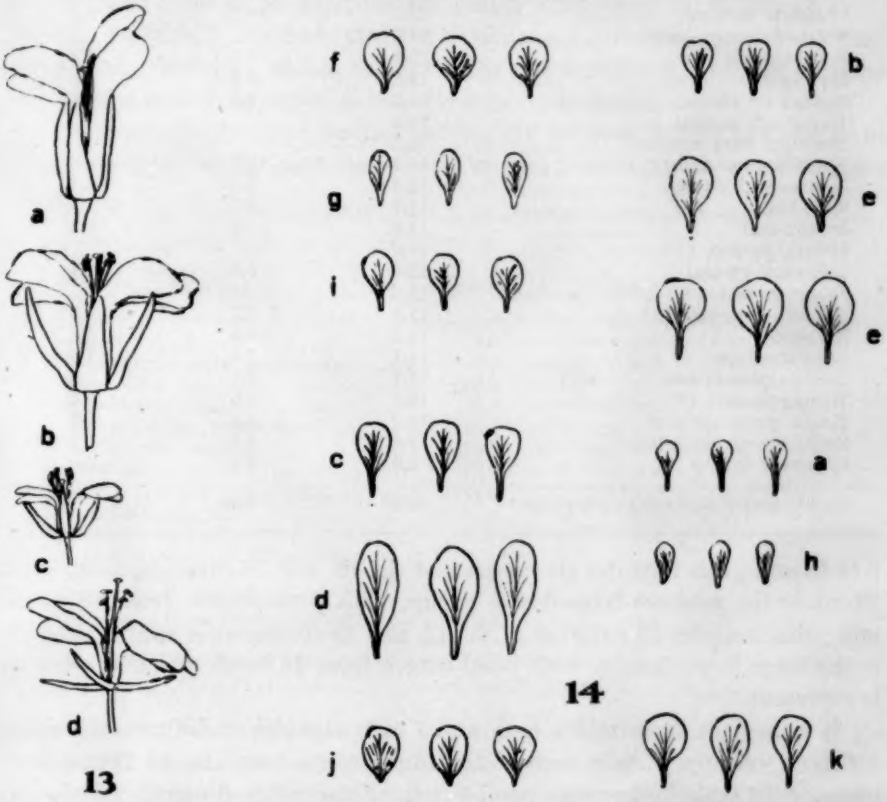


FIG. 13. Types of sepals of some species of *Brassica* and of *Sinapis alba*. a, *B. oleracea* var. *gongylodes*; b, *B. napus* var. *napobrassica*; c, *B. juncea* var. *megarrhiza*; d, *B. juncea* var. *rugosa*. FIG. 14. Shape of petals of species of *Brassica* and of *Sinapis alba*. a, *B. nigra*; b, *B. juncea* var. *gracilis*; c, *B. carinata*; d, *B. oleracea* var. *acephala*; e, *B. napus* var. *oleifera*; f, *B. chinensis* var. *pandurata*; g, *B. campestris* var. *oleifera*; h, *B. campestris* var. *rapifera*; i, *Sinapis alba*.

Evidently great variation in petal size exists among different varieties and species of *Brassica*. Bailey's observation may generally be considered correct, but his classification into large-flowered and small-flowered groups is not entirely satisfactory. Perhaps *Brassica* may be fairly accurately divided into four groups by petal length. First is the small-flower group, with petal-length from 7 to 9 mm.; *B. nigra* and a few varieties of *B. rapa* are representative. Second is the medium-small-flower group, with petal-length from

TABLE 5. *Mean length and width of petals of different varieties and species of Brassica (1941).*

Common name	Length (mm.)	Width (mm.)	Length / Width
Yellow-flowered kale	23.9	11.9	2.0
Common cabbage	23.6	10.2	2.3
White-flowered kale	21.3	.....	.....
Red kohlrabi	20.8	8.5	2.4
Meitan siao-yu-tsai	13.2	9.8	1.3
Meitan da-yu-tsai	12.5	6.3	2.0
Kiangmen pe-tsai	12.4	.....	.....
Kwangsi long-petioled	12.3	.....	.....
Kweilin hwa-tsai (1)	12.2	7.7	1.6
Nanfeng chieh-tsai	11.8	7.0	1.7
Tson-tsai	11.7	5.0	2.3
Da-tou-tsai	11.6	5.4	2.1
Hwang-ya-tsai (1)	11.6	.....	.....
Shiantan yu-tsai	11.6	6.9	1.7
Ishan pe-tsai	11.6	.....	.....
Kweilin hwa-tsai (2)	11.4	7.7	1.5
Rutabaga	11.2	6.6	1.7
Ling-chiao-tsai	11.1	5.8	1.9
Pe-hwa piao-er-tsai	11.1	8.1	1.4
Hwang-ya-tsai (2)	10.7	6.9	1.5
Kasin green-petioled	10.2	5.8	1.7
Shealiehung chieh-tsai	9.8	4.6	2.1
Snowball turnip	9.0	4.5	2.0
Significant difference at 5% point	0.92	0.64	.....

9 to 13 mm.; this includes all varieties of the 10- and 18-chromosome species. Third is the medium-large-flower group, with petal-length from 13 to 17 mm.; this includes all varieties of the 17- and 19-chromosome species. Fourth is the large-flower group, with petal-length from 18 to 25 mm.; *B. oleracea* is representative.

It is evident from tables 5, 6, and 7 that significant differences among different varieties within each of the four groups may also be found. For instance, in table 5, the mean petal-length of the yellow-flowered kale is sta-

TABLE 6. *Mean length and width of petals of different species of Brassica (1943).*

Species	Length (mm.)	Width (mm.)	Length / Width
B. nigra (English source)	7.5	3.3	2.3
Sinapis alba (English source)	11.2	6.5	1.7
B. chinensis var. *pandurata*	13.0	9.0	1.4
B. campestris (English source)	11.1	6.3	1.8
B. carinata (English source)	16.0	7.7	2.1
B. juncea var. *orthocarpa*	12.4	6.4	1.9
B. napus (English source)	14.9	8.4	1.8
B. napella (Japanese source)	15.3	9.7	1.6
Significant difference at 5% point	0.46	0.34	.....

tistically greater than that of white-flowered kale or red kohlrabi. Meitan siao-yu-tsai may be considered as having the longest and snowball the shortest petals in the medium-small-flower group, and significant differences may be found among these varieties. From table 6 it may be seen that the petals of *B. chinensis* var. *pandurata* are significantly longer than those of *B. campestris*, and those of *B. carinata* are longer than those of *B. napus* or *B. napella*. In table 7, one finds that the petal-length difference between *B. chinensis* var. *pandurata* and *B. campestris* is also significant, but that between *B. carinata* and *B. napus* or *B. napella* is not significant.

There is a fairly close positive correlation between length and width of petals except in Meitan siao-yu-tsai and pe-hwa piao-er-tsai, whose petals are

TABLE 7. *Mean length and width of petals of different species of Brassica (1944).*

Species	Length (mm.)	Width (mm.)	$\frac{\text{Length}}{\text{Width}}$
B. nigra	8.9	3.6	2.5
B. rapa (extra early purple top)	7.6	3.2	2.4
Sinapis alba	10.5	5.8	1.8
B. campestris	9.7	4.8	2.0
B. chinensis var. *pandurata*	11.5	8.2	1.4
B. juncea var. *gracilis*	10.7	6.0	1.8
B. carinata	13.7	6.8	2.0
B. napus	14.0	7.6	1.8
B. napella	13.4	8.7	1.5
B. oleracea var. *acephala*	21.7	7.8	2.8
(*B. campestris* × *B. chinensis* var. *pandurata*) F_1	11.6	6.9	1.7
(*B. napus* × *B. campestris*) F_1	12.4	7.7	1.6
(*B. napus* × *B. campestris*) F_1–21	10.9	4.4	2.5
Significant difference at 5% point	0.70	0.49	0.16

very wide. In this connection, one may direct attention to the shape of the petals. The length-width ratio would be a factor in determining the shape; this will lead to the differentiation of the narrow-petaled and broad-petaled forms of *Brassica*. Another factor in petal-shape is the length of the claw. The writer has observed that the petals of some species are very long-clawed, and those of others very short-clawed (fig. 14). Bailey noted in his key to the *oleracea-napus* group that their petals are long-tapering to narrow bases, while in the *campestris-juncea* group they are said to be less prominently tapering. It can be seen from figure 17 that *B. chinensis* var. *pandurata* may be considered as a typical short-clawed variety and *B. rapa* (extra early purple top) has no claw at all; others, such as *B. nigra*, *B. juncea*, *B. oleracea*, *B. napus*, and *B. carinata* are all long-clawed; *Sinapis alba* is also long-clawed but the petals are rather abruptly constricted between limb and claw, not gradually tapering toward the base.

The mode of inheritance of these differences in size and shape of petals of *Brassica* seems not to have been investigated.

11. Petal Color. Bailey stated that the petals of *B. oleracea, B. napus,* and allied species were cream-yellow, very light yellow, ochroleucous, or white, and those of other species were bright yellow or sulphur-yellow. The writer has found that the petals of the *juncea-chinensis* group are not always bright yellow or sulphur-yellow. The petals of the new type of *B. chinensis,* pe-hwa piao-er-tsai, are white, but at the point of inflection of the claw there is a very light yellow color. In addition to this type, other types of white petals have been found in the *juncea-chinensis* group. Petals have often been found in Meitan siao-yu-tsai (*B. chinensis* var. *pandurata*) which are not so white as those of pe-hwa piao-er-tsai, with a little more yellow pigment distributed throughout the petal. Another sort of white petal is found in Meitan da-yu-tsai (*B. juncea* var. *gracilis*); its appearance is much like that of white-flowered siao-yu-tsai. A cross of white-petaled siao-yu-tsai × normal yellow results in normal yellow F_1 and a ratio of 3 yellow to 1 white in F_2. The yellow of the F_2 segregates is not uniform; three grades—intensified yellow, normal yellow, and greenish-yellow—may be identified. Similarly two grades—parental white and yellowish-white—may be identified among the white-petaled progeny.

The F_1 of white-petaled da-yu-tsai × normal yellow has also been obtained. The petal color of the hybrid is normal yellow. A ratio of 12 normal yellow : 3 light yellow : 1 parental white is obtained in the F_2 generation when the F_1 plants are selfed. This suggests a 2-gene hypothesis.

Petals of the F_1 plants of pe-hwa piao-er-tsai × yellow-petaled wild type siao-yu-tsai are lemon-yellow. When the F_1 was selfed, 14 normal yellow, 2 lemon yellow, and 5 white were obtained. The backcross progeny of pe-hwa piao-er-tsai × F_1 resulted in 33 lemon-yellow and 22 white-petaled plants. White petal of piao-er-tsai may differ from wild type yellow petal by a single gene.

Pearson (1929) and Kakizaki (1930), working independently on material from different sources, have reached the same conclusion, that the white corolla of *B. oleracea* is conditioned by a single dominant gene *Wh,* yellow being recessive. As regards the white-petaled form, Bailey considered it as a species under the name *B. alboglabra.* As far as evidence is available, such simply inherited differences, though of considerable interest, cannot be regarded as of taxonomic value, and exclusion of them in the delimitation of species will remove the most serious anomalies from the older classification. It is possible to select from commercial crops heterozygous plants of white-flowered *B. alboglabra* which will give progenies consisting of 75 per cent white-flowered *B. alboglabra* and 25 per cent yellow-flowered *B. oleracea*—two species within a single commercial variety.

12. Length and Shape of Silique. According to the writer's observations of the last three years, length and shape of silique should be considered as among the major taxonomic characters of *Brassica*. Classification of species based upon this character is found quite satisfactory. The siliques of all species of *Brassica* are essentially glabrous, but those of *Sinapis alba* are densely covered with stiff setose hairs. This should be regarded as one of the typical differences between *Brassica* and *Sinapis*. Also the silique of *Sinapis alba* is sharply constricted in the center and has seven ridges on each of the two valves (fig. 1, h). These also should be considered as major taxonomic characters. Moreover, the siliques of *B. nigra*, *B. juncea*, and *B. carinata* are all 4-sided, especially those of *B. nigra;* with no extra ridges except the four distinct edges (fig. 1). The external constrictions of these three species are not so prominent as those of *Sinapis alba*. The siliques of *B. chinensis*, *B.*

TABLE 8. *Mean length of silique in 22 specimens of Brassica (1941).*

Name	Mean length (mm.)	Name	Mean length (mm.)
Yellow-flowered kale	71.4	Meitan da-yu-tsai	31.7
Red kohlrabi	67.8	Snowball turnip	31.7
White-flowered kale	57.2	Horsetail da-yu-tsai	31.5
Green kohlrabi	54.4	Tson-tsai	31.4
Rutabaga	54.8	Ling-chiao-tsai	31.1
Meitan siao-yu-tsai	44.8	Ishan long-petioled	30.8
Chi-cho-yieh da-tou-tsai	37.9	Kwangsi long-petioled	27.5
Pe-pa-yieh da-tou-tsai	34.9	Chou-chow chieh-tsai	27.4
Kiangmen pe-tsai	34.6	Nanfeng chieh-tsai	25.6
Meitan hwangi-ya-tsai	33.2	Pe-hwa piao-er-tsai	20.2
Kweilin hwa-tsai	32.7	Shealiehung chieh-tsai	20.2

Significant difference at 5% point: 6.36 mm.

oleracea, and *B. napus* are all practically glabrous; no distinct ridges can be found on their surfaces and they are elliptic in cross section.

Considering the length of silique exclusive of the beak, one finds very remarkable differences among species (tables 8–10). Ten random measurements in each of 22 specimens and 20 measurements in each of 5 species of *Brassica* were made in 1941 and 1943 respectively. In 1944, 10 random measurements in each of 15 specimens were made. The differences necessary for significance were determined by analysis of variance. The variance between species or varieties were significantly greater than that within each class, indicating real differences among the species and varieties of *Brassica*.

The siliques of *B. nigra* and *Sinapis alba* are significantly shorter than those of any other species. Bailey mentioned that the fruit of *B. nigra* is short, less than 1 inch long, and that of *Sinapis alba* 0.75–1.5 inches long. However, the writer has not found one fruit of *Sinapis alba* which exceeded 15 mm. in length in samples taken over two years, and no silique of *B. nigra* was found to exceed 14 mm. in length.

TABLE 9. *Mean length of silique in 5 species of Brassica (1943).*

Species	Mean length (mm.)
B. nigra	11.0
Sinapis alba	12.0
B. juncea var. *gracilis*	29.2
B. carinata	30.0
B. napella	48.5
Significant difference at 5% point: 1.65 mm.	

It can be seen from table 10 that the lengths of siliques of different species of *Brassica* are quite variable in nature. The range of variation may be as small as 3 mm., as in *B. nigra,* and as large as 41 mm., as in hwang-ya-tsai. High variability is associated with long siliques and low with short. It would be unfair to use a generalized experimental error for comparing different species-means within certain large-silique groups or within certain small-silique groups. On account of this relation, three groups—large-, medium-, and small-silique groups—have been separated according to the range of variation and the mean lengths of silique. Analysis of these groups gave quite different variances within species.

In general, the siliques of the 9- and 19-chromosome species are very long.

TABLE 10. *Ten random measurements of length of silique in each of 15 specimens of Brassica (1944).*

Name	Lengths of silique (mm.)										Mean length (mm.)
B. napus	68	68	61	58	71	66	61	59	42	45	59.9
B. napobrassica	53	53	51	55	55	53	57	49	50	38	51.4
B. oleracea var. *acephala*	60	62	75	73	73	76	74	61	62	54	67.0
B. campestris	60	60	52	54	47	43	44	42	30	22	45.4
Hwang-ya-tsai (special)	69	69	70	72	54	52	43	40	37	31	53.7
Significant difference at 5% point for above: 9.67 mm.											
Da-chieh-tsai	40	40	42	39	39	33	38	39	33	25	36.8
Da-yu-tsai	31	33	33	31	32	35	30	31	33	23	31.2
B. carinata	35	35	34	32	33	27	31	26	22	18	29.3
B. campestris	36	34	37	36	35	26	27	28	19	38	31.6
Extra early purple top	23	32	35	31	42	47	48	41	31	25	35.5
Siao-yu-tsai	37	38	35	37	38	40	35	30	22	20	33.2
Pe-hwa piao-er-tsai	27	25	26	27	28	24	26	21	21	18	24.3
Significant difference at 5% point for above: 5.28 mm.											
B. nigra	10	13	12	10	11	11	10	12	12	11	11.2
Sinapis alba	7	13	12	12	13	10	12	11	11	12	11.3
Shealiehung chieh-tsai	17	20	18	21	20	20	19	20	18	18	19.1
Significant difference at 5% point for the above: 1.28 mm. Significant difference at 5% point for all species: 6.56 mm.											

The mean lengths range from 48.5 mm. in *B. napella* (table 9) to 71.4 mm. in yellow-flowered kale (table 8). But the mean lengths of silique of nearly all varieties of *B. juncea, B. chinensis, B. rapa,* and *B. carinata* are rather short, from 19.1 mm. in Shealiehung chieh-tsai (table 10) to 37.9 mm. in chi-cho-yieh da-tou-tsai (table 8). Table 8 shows that the mean length of siliques of Meitan siao-yu-tsai is 44.8 mm., which is significantly less than the mean length of the siliques of rutabaga or green kohlrabi but greater than that of chi-cho-yieh da-tou-tsai. As shown in table 10, the mean length of siliques of another type of siao-yu-tsai in Meitan is 33.2 mm., which is also significantly less than that of the long-silique species but not significantly different from that of the medium-silique species. In which group should Meitan siao-yu-tsai be included? In a study of correlation of characters of siao-yu-tsai in Hangchow, Sun and Chon (1930) reported the estimated mean length of the siliques, including the beak, as 57.1 mm. The estimated standard deviation was 11.7 mm. and the range of variation 30.1–95.0 mm. Considering these data, it seems safe to include siao-yu-tsai in the long-silique group.

The variation in silique-length of different types of *B. campestris* and of hwang-ya-tsai is also great. Identification of these species should only doubtfully be based on silique-length alone.

It follows from present data that species of *Brassica* may generally be placed in three groups according to silique-length:

1. Short-silique group; mean length 11.0–12.0 mm.; range of variation 7–15 mm.; species: *B. nigra, Sinapis alba.*

2. Medium-silique group; mean length 19.1–37.9 mm.; species: *B. campestris, B. rapa, B. chinensis, B. juncea, B. carinata.*

3. Long-silique group; mean length 44.8–71.4 mm.; species: *B. oleracea, B. napus* (*B. napella*), *B. campestris, B. chinensis* var. *pandurata* and var. *pekinensis.*

13. Length and Shape of the Beak of Silique. Length and shape of beak should also be considered as important taxonomic characters. Bailey used this character to separate *Brassica* (*Sinapis*) *alba* from other species. He placed *B. nigra* and all 10- and 18-chromosome species under the heading "beak of mature silique slender or conical, terete in section, not seed-bearing," while *B. alba* is found under the heading "beak of mature silique long and flat or two-edged, usually or often containing a seed in the indehiscent cell." The above distinction may generally be considered correct, but the writer has found no seed in the beak of *Sinapis alba;* it is essentially flat, scythe-shaped, equaling or exceeding the fruit body, in these ways quite different from all species of *Brassica* proper.

Bailey also pointed out that the beak of *B. napus* is mostly more than

TABLE 11. *Mean length of beak in 22 specimens of Brassica (1941).*

Name	Length of beak (mm.)	Name	Length of beak (mm.)
Meitan siao-yu-tsai	19.7	Red kohlrabi	7.7
Rutabaga	11.7	Common da-tou-tsai	7.6
Yellow-flowered kale	11.3	White-flowered kale	7.4
Snowball turnip	9.3	Nanfeng chieh-tsai	7.4
Kiangmen pe-tsai	9.1	Chi-cho-yieh da-tou-tsai	7.3
Horsetail da-yu-tsai	8.8	Tson-tsai	7.3
Kwangsi long-petioled	8.7	Shealiehung chieh-tsai	6.9
Ishan long-petioled	8.7	Chou-chow chieh-tsai	6.9
Meitan hwang-ya-tsai	8.1	Kweilin hwa-tsai	6.3
Meitan da-yu-tsai	8.0	Ling-chiao-tsai	5.3
Green kohlrabi	7.9	Pe-hwa piao-er-tsai	4.9

Significant difference at 5% point: 1.87 mm.

TABLE 12. *Mean length of beak in 5 specics of Brassica (1943).*

Species	Mean length of beak (mm.)
B. nigra	2.9
Sinapis alba	14.9
B. juncea var. *gracilis*	6.7
B. carinata	3.6
B. napella	17.3

Significant difference at 5% point: 0.87 mm.

TABLE 13. *Mean length of beak in 15 specimens of Brassica (1944).*

Name	10 measurements of length of beak (mm.)										Mean
B. napus	16	18	16	16	16	16	17	15	14	16	16.0
B. napobrassica	12	12	11	10	12	12	11	11	12	9	11.2
B. campestris (1)	25	24	23	25	20	17	13	11	13	10	18.1
Extra early purple top	8	10	19	18	22	19	18	16	13	10	15.3
B. campestris (2)	18	14	18	16	18	12	11	11	10	17	14.5
Hwang-ya-tsai (special)	11	12	14	14	11	9	10	8	6	8	10.3
Sinapis alba	10	15	14	14	15	12	13	14	13	14	13.4
Significant difference at 5% point of above: 3.04 mm.											
B. oleracea var. *acephala*	8	8	7	6	7	7	8	6	7	5	6.9
Siao-yu-tsai (var. *pandurata*)	6	7	6	5	6	6	4	5	3	3	5.1
Pe-hwa piao-er-tsai	6	7	8	7	8	6	6	4	5	4	6.1
Da-yu-tsai (var. *gracilis*)	8	8	8	9	9	10	8	9	6	7	8.2
Shealiehung chieh-tsai	5	4	6	6	6	6	7	6	4	6	5.6
Ba-chieh-tsai (*rugosa*)	9	9	8	8	7	7	8	8	6	7	7.7
B. carinata	4	4	3	3	4	3	3	3	4	3	3.4
B. nigra	2	3	3	3	3	3	3	3	3	4	3.0

Significant difference at 5% point for above: 0.92 mm.
Significant difference at 5% point for all species: 2.16 mm.

1 cm. long, that of *B. napobrassica* usually less than 1 cm., and that of *B. napiformis* less than 8 mm.

For a study of the length of the beak, 10 random measurements in each of 22 specimens, 20 measurements in each of 5 species, and 10 measurements in each of 15 specimens of *Brassica* were made in 1941, 1943, and 1944 respectively (tables 11–13).

The mean beak-length of specimens examined may be classified in two main groups, a long-beak class and a short-beak class. The long-beak class includes *Sinapis alba*, all 19-chromosome species, and some of the 10-chromo-

TABLE 14. *Silique-beak ratio in 15 specimens of Brassica in 1944.*

Name	Mean silique–beak ratio based on 10 computations	Range of variation
Sinapis alba	0.8	0.2
B. rapa	2.4	1.4
B. campestris (1)	2.6	1.7
B. campestris (2)	2.2	0.6
Significant difference at 5% point for above: 0.35.		
B. napus	3.7	1.6
B. napobrassica	4.6	1.3
Hwanga-ya-tsai (special)	5.3	2.3
Pe-hwa piao-er-tsai	4.1	2.0
Da-yu-tsai	3.9	2.2
Da-chieh-tsai	4.8	2.0
Shealiehung chieh-tsai	3.5	2.3
B. nigra	3.8	2.2
Siao-yu-tsai	6.7	3.3
Significant difference at 5% point for above: 0.55.		
B. oleracea var. *acephala*	9.8	4.7
B. carinata	8.7	5.8
Significant difference at 5% point for above: 1.58. Significant difference at 5% point for all specimens: 0.71.		

some specimens. The short-beak class includes *B. nigra, B. carinata,* all 9- and 18-chromosome specimens, and some of the 10-chromosome specimens. Table 11 shows that Meitan siao-yu-tsai belongs to the long-beak class and the beak-length variation of other specimens including the 9-, 10-, 18-, and 19-chromosome species ranges from 4.9 to 11.7 mm. There is practically no clear-cut line in the classification of species; consequently it was thought that the ratio of beak-length to silique-length might be more applicable than beak-length alone in classifying species. This ratio computed for 15 specimens in 1944, 5 species in 1943, and 22 specimens in 1941, is shown in tables 14–16.

The variation of the silique-beak ratio is essentially continuous and no clear-cut line can be drawn to separate groups. One outstanding feature

TABLE 15. *Mean siliqeu–beak ratio in 5 species of Brassica (1943).*

Species	Mean silique–beak ratio
B. nigra	4.0
Sinapis alba	0.8
B. juncea var. *gracilis*	4.4
B. carinata	8.4
B. napella	2.8

Significant difference at 5% point: 0.49.

should be mentioned: the mean silique-beak ratio of *Sinapis alba* was found to be 0.822 and 0.841 in 1943 and 1944 respectively, definitely showing that the beak length exceeds the silique length. This should be regarded as an identifying character which does not occur in other species.

Kohlrabi, kale, and *B. carinata* may be considered as the short-beak species in terms of silique length. Some types of Meitan siao-yu-tsai, *B. campestris,* and the extra early purple top turnip may be considered as the long-beak type. Other specimens, including *B. nigra, B. napus,* rutabaga, and varieties of *B. chinensis* and of *B. juncea* can hardly be separated by silique-beak ratio.

14. Angle between Pedicels and Rachis. It is found in *Brassica* that the angle between pedicels and rachis differs in different species. Pedicels of *B. nigra* are closely appressed to the rachis, and Bailey has considered this as typical of that species. The writer has found that this character is not confined to *B. nigra* but is found also in *B. juncea.* Horsetail da-yu-tsai (*B. juncea* var. *orthocarpa*) is characterized by the same sort of ascending pedicels as *B. nigra.*

Besides the extreme type of *B. nigra,* the angle between pedicels and rachis varies widely in other species. The pedicels of *B. napella* and *Sinapis alba* are practically perpendicular to the rachis; while in other species different angles are found in different varieties. For a study of the variation in

TABLE 16. *Mean silique–beak ratio in 22 specimens of Brassica (1941).*

Name	Mean ratio	Name	Mean ratio
Meitan siao-yu-tsai	2.3	Pe-hwa piao-er-tsai	4.1
Shealiehung chieh-tsai	2.9	Tson-tsai	4.3
Kwangsi long-petioled	3.2	Common da-tou-tsai	4.6
Snowball turnip	3.4	Rutabaga	4.7
Ishan long-petioled	3.5	Kweilin hwa-tsai	5.2
Nanfeng chieh-tsai	3.5	Chi-cho-yieh da-tou-tsai	5.2
Horsetail da-yu-tsai	3.6	Ling-chiao-tsai	5.9
Kiangmen pe-tsai	3.8	Yellow-flowered kale	6.3
Meitan da-yu-tsai	4.0	Green kohlrabi	6.9
Chou-chow chieh-tsai	4.0	White-flowered kale	7.7
Meitan hwang-ya-tsai	4.1	Red kohlrabi	8.8

TABLE 17. *Mean angles between pedicels and rachis in 3 specimens of Brassica (1941).*

Name	Mean angle (based on 20 measurements)
Meitan siao-yu-tsai	65.2°
Meitan da-yu-tsai	48.0°
Horsetail da-yu-tsai	14.7°

Significant difference at 1% point: 9.298°.

this angle, 20 measurements in each of three specimens were made in 1941. Table 17 indicates that the mean angle formed between pedicels and rachis in horsetail da-yu-tsai is acute, which means that the silique is appressed to the rachis. Meitan siao-yu-tsai represents the wide-spreading type but the angle does not reach 90 degrees. Meitan da-yu-tsai represents the intermediate type, the angle being about 45°.

15. Number of Seeds per Silique. It has been pointed out that the length of silique may be considered important in the classification of species of *Brassica*. It is easily realized that the number of seeds per silique may also be of use. Sun and Chon (1930) reported that the mean number of seeds per silique in Hangchow siao-yu-tsai, estimated from 87 individuals, was 32.89; the estimated standard deviation was 3.8, and the total range of variation 24–42. For a study of the variation in number of seeds per silique, 10 random counts in each of 6 and 15 specimens of *Brassica* were made in 1943 and 1944 respectively. It can be seen from tables 18 and 19 that significant variation in number of seeds per silique occurs in different species. Analogous to the silique-length groups, three groups may generally be separated according to the mean number of seeds per silique, as follows:

1. Small-silique group; seeds per silique from 1 to 8; mean number of seeds 3.3–5.6; species included: *B. nigra, Sinapis alba.*
2. Medium-silique group; seeds per silique from 9.6 to 20.6; species included: *B. campestris, B. chinensis, B. carinata,* and *B. juncea.*

TABLE 18. *Number of seeds per silique in different species of Brassica (1943).*

Species	10 random counts										Mean
B. alba	3	4	2	4	4	4	4	3	5	5	3.8
B. nigra	6	3	5	5	8	7	5	6	4	7	5.6
B. carinata	14	7	12	13	13	12	10	8	8	15	11.2
Da-yu-tsai	18	14	14	14	13	14	13	16	14	15	14.5
Siao-yu-tsai	23	22	23	23	23	23	27	14	11	17	20.6
B. napella	26	27	27	26	14	17	29	27	23	24	24.0

Significant difference of means at 5% point: 2.86.

3. Large-silique group; seeds per silique from 24 to 30.6; species included: *B. oleracea*, *B. napus* (*B. napella*), and *B. chinensis* var. *pandurata*. (In Hangchow siao-yu-tsai, the range of variations was from 24 to 42 seeds per silique.)

16. Color and Size of Seeds. Color and size of seeds of different species and varieties of *Brassica* vary greatly. Sun (1937) examined the variation in weight of 50 seeds in relation to seed color of inbred lines of Hangchow siao-yu-tsai. His results are reproduced in table 20. They distinctly indicate a wide variation in seed size among these inbred lines. A test for indepen-

TABLE 19. *Number of seeds per silique in different species of Brassica (1944).*

Name	10 random counts										Mean
Hwang-ya-tsai (special)	25	30	25	30	14	8	6	4	5	2	14.9
Meitan siao-yu-tsai	24	25	23	21	24	30	22	17	3	3	19.2
B. campestris (1)	17	27	22	27	16	19	28	23	2	4	18.5
Extra early purple top	3	5	9	8	10	23	16	12	5	5	9.6
B. campestris (2)	17	20	20	19	21	5	10	11	4	19	14.6
B. carinata	15	15	18	15	13	12	11	11	5	4	11.9
B. juncea var. *rugosa*	17	20	18	16	14	11	20	19	16	6	15.7
Pe-hwa piao-er-tsai	21	20	16	17	21	15	16	13	11	8	15.8
B. juncea var. *gracilis*	14	16	13	14	14	15	16	15	16	6	13.9
Significant difference of means of above at 5% point: 6.25.											
B. napus	31	35	27	21	34	30	26	25	11	14	25.4
B. napobrassica	29	23	30	28	28	24	31	22	25	13	25.3
B. oleracea var. *acephala*	26	27	36	38	33	38	36	28	25	19	30.6
Significant difference of means of above at 5% point: 6.14.											
B. nigra	5	6	4	5	4	4	3	5	5	5	4.6
Sinapis alba	1	4	3	4	5	2	3	4	3	4	3.3
Shealiehung chieh-tsai	9	11	9	12	11	8	10	9	8	9	9.6
Significant difference of means of the above at 5% point: 1.04. Significant difference of means of all species at 5% point: 5.51.											

dence of the data gave $X^2 = 11.637$. For 5 degrees of freedom p would fall between 0.05 and 0.02, indicating that an association exists between seed color and seed size, large seed being associated with yellow and small seed with red or purple color.

For a detailed study of the variation in seed size of different species and varieties, seed weights were determined for 2 random samples of 50 seeds in each of 44 specimens and 2 random samples of 100 seeds in each of 49 specimens in 1941 and 1943 respectively (tables 21–24). It is seen from table 21 that seed size varies greatly even within groups of the same number of chromosomes. In general, seed size of the 10-chromosome group may be considered as larger than that of the 18-chromosome group (table 23). Table 24 shows

TABLE 20. *Frequency distribution of seed weight in relation to seed color.*

Wt. of 50 seeds (g.)	Number of plants with seeds		
	Purple or red	Yellow	Total
0.10–0.13	7	5	12
0.13–0.14	5	6	11
0.14–0.15	17	13	30
0.15–0.16	17	23	40
0.16–0.17	7	13	20
0.17–0.29	9	33	42
Total	62	93	155

TABLE 21. *Mean weight of 50 seeds and seed color of different species and varieties of Brassica (1941).*

Name	Seed color	Weight of 50 seeds	Calculated for 100 seeds
Green kohlrabi	Purple	0.22	0.45
Red kohlrabi	Purplish-brown	0.15	0.30
White-flowered kale	Purplish-black	0.14	0.29
Yellow-flowered kale	Purplish-black	0.13	0.26
Rutabaga	Purplish-black	0.10	0.21
Siao-yu-tsai (1)	Yellow	0.20	0.40
Siao-yu-tsai (2)	Yellow	0.17	0.35
Siao-yu-tsai (3)	Yellow	0.17	0.35
Siao-yu-tsai (4)	Purplish-brown	0.15	0.30
Siao-yu-tsai (5)	Yellow	0.15	0.30
Siao-yu-tsai (6)	Yellow	0.14	0.29
Siao-yu-tsai (7)	Purplish-brown	0.14	0.29
Long-petioled pe-tsai	Purplish-black	0.10	0.20
Kweilin hwa-tsai (1)	Purplish-brown	0.10	0.21
Tze-kiang siao-yu-tsai	Purplish-black	0.09	0.18
White-petaled siao-yu-tsai (1)	Yellow	0.09	0.18
Pe-hwa piao-er-tsai	Reddish-brown	0.09	0.17
Kweilin hwa-tsai (3)	Purplish-brown	0.08	0.17
Kweilin hwa-tsai	Purplish-brown	0.08	0.16
Loehsiang siao-yu-tsai	Purplish-black	0.08	0.16
Hybrid turnip	Purple	0.07	0.14
Yuanlin siao-yu-tsai	Purplish-black	0.07	0.14
White-petaled siao-yu-tsai (1)	Yellow	0.07	0.13
Pe-tsai	Purplish-black	0.07	0.13
Siontan siao-yu-tsai	Purplish-black	0.06	0.13
30-day early tsai-tai	Purplish-brown	0.06	0.13
Kasin short-petioled	Purplish-brown	0.06	0.12
Snowball turnip	Purplish-brown	0.04	0.08
Ling-chiao-tsai	Purplish-black	0.08	0.16
Da-tou-tsai	Brown	0.08	0.16
Chou-chow chieh-tsai	Brown	0.07	0.13
Red-leaf chieh-tsai	Black	0.07	0.13
Dinfan (4) da-yu-tsai	Purplish-brown	0.07	0.13
San-yeu-chin chieh-tsai	Purple	0.06	0.13
White-petaled da-yu-tsai	Yellow	0.06	0.13
Horsetail da-yu-tsai	Brown	0.06	0.13
Hsu-pu da-yu-tsai	Purplish-brown	0.06	0.12
Ping-yeu da-yu-tsai	Purplish-brown	0.05	0.11
Yellow-leaf chieh-tsai	Purplish-brown	0.05	0.10
Nanfeng chieh-tsai	Purplish-brown	0.04	0.08
Wild da-yu-tsai	Reddish-brown	0.04	0.09
Ping-yeu (1) da-yu-tsai	Purplish-brown	0.04	0.09
Shealiehung chieh-tsai	Brown	0.04	0.08
Tson-tsai	Brown	0.03	0.05

TABLE 22. *Frequency distribution of seed weight in relation to number of chromosomes (1941).*

Weight of 100 seeds (g.)	Number of varieties having		Total
	$n = 10$	$n = 18$	
0.05–0.12	2	7	9
0.12–0.16	7	9	16
0.16–0.20	5	0	5
0.20–0.32	6	0	6
0.32–0.40	3	0	3
Total	23	16	39

TABLE 23. *Weight of 100 seeds in each of 49 varieties of rape (1943).*

Name	Seed color	Mean wt. of 100 seeds (g.)
Siao-yu-tsai (y × w) F_2	Yellow	0.38
Siao-yu-tsai (1)	Yellow	0.37
Siao-yu-tsai (2)	Yellow	0.36
Siao-yu-tsai (70)	Yellow	0.33
Siao-yu-tsai × Kweilin hwa-tsai F_2	Purple	0.33
Siao-yu-tsai (3)	Yellow	0.32
Ishan siao-yu-tsai	Purple	0.32
Bitter siao-yu-tsai	Purple	0.32
Siao-yu-tsai (y × p) F_2	Yellow & purple	0.31
Yuanlin siao-yu-tsai	Purple	0.30
Szermen siao-yu-tsai	Purple	0.30
Tze-kiang siao-yu-tsai	Purple	0.30
Lu-chie siao-yu-tsai	Purple	0.30
White-petaled siao-yu-tsai	Yellow	0.30
Lee-hsiang siao-yu-tsai	Purple	0.29
Siontan siao-yu-tsai	Purple	0.29
Pe-hwa piao-er-tsai × siao-yu-tsai F_2	Purple	0.27
Pe-hwa piao-er-tsai × wild siao-yu-tsai F_2	Purple	0.21
Siao-yu-tsai commercial	Yellow	0.20
B. napella	Deep purple	0.25
Da-yu-tsai dinfan (4)a	Deep purple	0.27
Da-yu-tsai pinyeh (2)	Deep purple	0.24
Da-yu-tsai commercial (1)	Purple	0.22
Da-yu-tsai (101)	Yellow	0.22
Da-yu-tsai commercial (2)	Yellow	0.22
Da-yu-tsai pinyeh (4)	Purple	0.22
Da-yu-tsai hwanpin (2)	Purple	0.22
Da-yu-tsai loo-dieh (1)	Purple	0.21
Da-yu-tsai (104)	Yellow	0.21
Da-yu-tsai dinfan (4)b	Purple	0.21
Da-yu-tsai changsei (4)	Purple & yellow	0.21
Da-yu-tsai (106)	Yellow	0.21
Da-yu-tsai (110)	Yellow	0.20
Da-yu-tsai (96)	Yellow	0.20
Da-yu-tsai commercial	Yellow	0.20
Da-yu-tsai (107)	Yellow	0.20
Da-yu-tsai pingchow (2)	Purple	0.20
Da-yu-tsai kwenlin (2)	Purple	0.20
Da-yu-tsai pinyeh (1)	Purple	0.19
Da-yu-tsai (102)	Yellow	0.19
Da-yu-tsai sze-pim (2)	Purple	0.18
Horsetail da-yu-tsai	Yellow	0.18
Da-yu-tsai shepu sweet	Purple	0.18
White-petaled da-yu-tsai	Yellow	0.17
(Tson-tsai × da-yu-tsai) F_2	Purple	0.16
(Shealiehung × white-petaled da-yu-tsai) F_2	Purple	0.15
(Tson-tsai × Shealiehung) F_2	Purple	0.14
Tson-tsai	Purple	0.14
Shealiehung	Purple	0.13

significant variation in seed size among the 49 varieties tested. Analogous to the 1941 results, variation is also great within groups having the same number of chromosomes (table 25).

TABLE 24. *Frequency distribution of seed weight in relation to number of chromosomes of two Chinese species of rape (1943).*

Weight of 100 seeds	Number of varieties having		Total
	$n = 10$	$n = 18$	
0.101–0.15	0	4	4
0.151–0.20	0	12	12
0.201–0.25	2	12	14
0.251–0.30	6	1	7
0.301–0.35	8	0	8
0.351–0.40	3	0	3
Totals	19	29	48

Although there is association between seed size and species groups, owing to the continuous and overlapping distribution of their frequencies the two groups can hardly be separated by seed size alone. Size of seed, therefore, can be considered as only minor for taxonomic purposes.

As to seed color variation, many shades from purplish-black to light yellow have been observed in both 10- and 18-chromosome species. The presence or absence of pigment and its genetic nature were not investigated until recently. Varietal crosses were made between yellow and purple seed-types of *B. juncea* in the spring of 1941. Breeding experiments have shown that purple was dominant over yellow, as indicated by the phenotype of the F_1 hybrid. In certain F_2 populations, a segregation of 15 purple and red to 1 yellow was obtained. Another population showed a ratio of 3 red to 1 yellow. A back cross progeny of the yellow-seeded parent by an F_1 plant showed a ratio of 3 red to 1 yellow, which confirms the duplicate factor hypothesis suggested by the F_2.

From the above results it may be safe to conclude that color and size of seed of *B. chinensis* and *B. juncea* can be regarded as useful for identifying agricultural varieties within these two species, but not adequate for differentiation of species in general.

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BANISTERIA CAAPI SPRUCE: ITS CHROMOSOMES[1]

J. T. BALDWIN, JR.

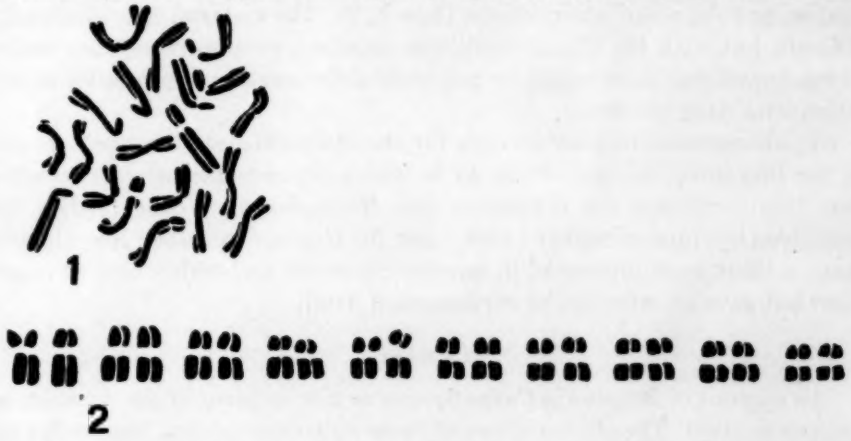
Not a few of the scientifically minded travelers in the Amazonian region have written of *"Caapi": Banisteria Caapi* Spruce. Ducke (1943) states that the pronunciation in *lingua geral* conforms to the spelling *"capi."* And, of course, there are other popular designations for the plant, which is a shrubby vine of the Malpighiaceae. Richard Spruce, in the 1850's, was acquainted with its cultivation as a drug plant by the Indians on the upper tributaries of the Rio Negro in Amazonas, Brazil, at the cataracts of the Orinoco in Venezuela, and in parts of eastern Peru and Ecuador. In a letter about *"Caapi"* Dr. Raymond M. Hann of the National Institute of Health has informed me that "the alkaloid is banisterine and it is identical with harmine," a derivative of one of the Rutaceae. Perhaps the best original account of *"Caapi"* and of the effects of its use by the Indians is that of Spruce (1908). A readable and general summary is given by Lewin (1931), who says that it "evokes mental disorders similar to the effects" of *Datura.*

The lower part of the stem is beaten in a mortar, and, after the woody debris is separated, the remainder is diluted with water and drunk. According to some writers the triturated material is boiled. Also, sometimes, parts of other plants are added to the preparation. The general effects of drinking *"Caapi"* seem to be: fluctuations in temperature, disturbance of sight, vomiting and vertigo, feelings of fear and of boldness, visions of things wonderfully pleasant and beautiful and of things horrible. Spruce (1908) stated: "In two minutes or less after drinking [a certain amount of] it, its effects begin to be apparent. The Indian turns deadly pale, trembles in every limb, and horror is in his aspect. Suddenly contrary symptoms succeed: he bursts into a perspiration, and seems possessed with reckless fury. . . . In about ten minutes the excitement has passed off, and the Indian grows calm,

[1] Morton (1930) gave the reasons for accepting the genus *Banisteriopsis* Robinson and (1931) assigned the plant here treated to it. In the latter paper he described *Banisteriopsis inebrians* and discussed its relations to *B. Caapi* and *B. quitensis:* all these are powerful drug plants. Though I know nothing of the merits of specific segregation in this particular aggregate, it is my impression that many groups of tropical plants are overnamed through a lack of understanding of genetic variation in those groups. And I wonder whether tropical floras—of the Amazonian region, for example—when they are well understood, will prove as rich in species as they now seem: from my own experience with *Hevea* Aubl. throughout much of its distribution area I judge that numerous Amazonian species undergo introgressive hybridization with resultant difficulties for herbarium studies and that many species in that region are characterized by ecotypes which at the hands of systematists are frequently accorded recognition in binomial terms. This is not to imply doubt on my part that hundreds of species await description.

but appears exhausted." According to Lewin (1931) Koch-Grünberg, who spent much time in northwest Amazonia, "drank two small calabashes of the magic liquor. After a short time he experienced, especially when he emerged into darkness, a peculiar scintillation in crude colours before his eyes. When writing, shadows like red flames passed over the paper. The dose was insufficient to enable him to experience the sensations produced in the Indians by this Phantasticum."

I have seen "*Caapi*" cultivated at Cucuhy, at the Venezuelan border, on the Rio Negro, in Amazonas, Brazil; shortly above the mouth of the Rio Uaupés, in Amazonas;[2] at the Campo Experimental, near Manáos, Amazonas, where it had been transplanted by Adolpho Ducke from the Rio Curicuriary, a tributary of the upper Rio Negro (a specimen is in the U. S. National



Chromosomes of *Banisteria Caapi* Spruce. FIG. 1. Metaphase plate from leaf of Manáos plant (originating from Rio Curicuriary). FIG. 2. Alignment of metaphase chromosomes from a colchicined leaf of Cucuhy plant. From preparations and drawings by Bernice M. Speese. Magnification *ca.* × 2000.

Herbarium: *Ducke 153*); and at Belém, Pará, Brazil. Cuttings from the plants at Cucuhy, Manáos, and Belém are now growing at The Blandy Experimental Farm.

The plants have not flowered in our greenhouse. No vegetative differences have been observed. Ducke (1943) described a new genus and species—*Cabi paraensis*—from plants cultivated at Belém, Pará, which, in a sterile condition, are distinguished from *B. Caapi* only by the thinner leaves of the

[2] In March, 1944, at Trovão on the Rio Uaupés, illness prevented my attending an all-night *fiesta* held by the Indians. When, after daybreak, I entered the house in which the celebration was still in progress, an Indian—just as recorded by Spruce almost a hundred years earlier—ran stumblingly from the opposite end of the house to offer me a calabash of what I think was "*Caapi*"; because of my condition, I refused the drink. The crowd was orderly and rather gay; they had been somewhat noisy during the night. Everybody there appeared to have been dusted with a white, flour-like substance.

latter. He states that the people of Pará "ignore" the narcotic properties of *Banisteria*. However, the native from whose house I obtained "*Caapi*" in Belém told me that a drink was made from it and that its leaves were bruised in water used for bathing. No other record of "*Caapi*" for ablutionary purposes has been encountered, and this report may be without significance.

Under favorable conditions the plant is a rampant grower. At the Campo Experimental in Manáos "*Caapi*" is at intervals crudely hacked to prevent its too great spread. If a considerable supply of the drug were needed, it could be readily produced.

With the assistance of Bernice M. Speese the chromosomes of three collections of *Banisteria Caapi* at The Blandy Experimental Farm have been examined in leaf smears. They all have a $2n$-number of 20 chromosomes, with median or submedian constrictions (figs. 1, 2). The material is cytologically difficult, but with the use of colchicine excellent preparations were made. It was hoped that there would be polyploid differences having possible correlation with drug content.

No chromosome-number records for the Malpighiaceae have been found in the literature. Nuclear divisions in which chromosomes are represented have been published for *Galphimia* and *Malpighia* by Stenar (1937), for *Malpighia* by Narasimhachar (1938), and for *Hiptage* by Subba Rao (1940): these authors were interested in megasporogenesis and embryo-sac development but gave no attention to chromosomal detail.

SUMMARY

An account of *Banisteria Caapi* Spruce as a drug plant of the Amazonian Indians is given. The chromosomes of three cultivated plants from different sources were examined: the $2n$-number is 20; the chromosomes have median or submedian constrictions. The plants studied did not differ vegetatively; they were not brought to flower. No other chromosome-number reports are known for the Malpighiaceae.

THE BLANDY EXPERIMENTAL FARM
BOYCE, VIRGINIA

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STUDIES IN THE SAPOTACEAE—V. THE SOUTH AMERICAN SPECIES OF CHRYSOPHYLLUM

ARTHUR CRONQUIST

In continuation of my studies on the American *Sapotaceae*, under the auspices of the Chicle Development Company, I have undertaken a revision of the South American species of *Chrysophyllum*. Thirty species are here recognized, two of which are known to me only from the original descriptions. Three new species are described. The species are, in general, well marked and sharply defined, and, with the exception of *C. marginatum*, do not show an unusual amount of intraspecific variability. The number of species still known from only one or a very few collections suggests that others remain to be discovered.

I have tried without success to prepare a reasonable phyletic scheme. Characters which would seem a priori to be primitive, such as attachment of the filaments toward the base of the corolla-tube, instead of at the throat, are rather consistently associated with apparently advanced features, such as villous anthers or long linear seed-scars. The implication of these difficulties is that the primitive species, and the ancestral home of the genus, are to be sought in the old world, where a number of species occur today. This conclusion is in accordance with the fact that several African species of *Chrysophyllum* often show vestigial staminodes (which are only very rarely seen in American plants), and that the primitive genera of the family are in the old world. I have tried to place related species together in the key and text, but the sequence here used has no other phyletic significance.

The failure of some workers to recognize the importance of seed-characters in the family, together with the fact that the seeds of many of the species are unknown, has led to the impression that the genera of the *Sapotaceae* are vague and ill-defined, but, while doubtful species and indefinite boundaries between genera certainly exist, these are of little more significance in proportion to the whole than in many other families. *Chrysophyllum* is distinguished from all other American *Sapotaceae* by the combination of albuminous seeds and lack of staminodes. In the absence of fruit, species of *Chrysophyllum* might be confused with the likewise astaminodial *Pradosia*, *Ecclinusa*, and *Oxythece*. *Pradosia* may then be distinguished by the abruptly tenuous distal portion of the filaments, which is reflexed in bud, *Ecclinusa* by the usual presence of stipules and by its habit, and *Oxythece* by the texture and venation of the leaves. These have the primary lateral veins obscure or impressed above, and not very prominent beneath, and the

secondary veins obscure on both sides or, if visible beneath, at least not raised. The lower surface of the leaves is more or less glaucous. Such a venation is rarely found in *Chrysophyllum*, although *C. arenarium* and forms of *C. marginatum* approach it. The glaucous lower leaf-surfaces of most species of *Oxythece* find no counterpart in *Chrysophyllum*. *Chrysophyllum imperiale* has a double bend near the middle of the filaments, but the filaments are of the same texture throughout, and the very large, toothed leaves of the species are enough to distinguish it at a glance not only from *Pradosia* but from all other species of *Chrysophyllum*. Other species of *Chrysophyllum* have straight or occasionally flexuous filaments of essentially uniform texture. *Chrysophyllum prieurii* and *C. cuneifolium*, while surely to be included in *Chrysophyllum*, resemble *Ecclinusa* in habit, and may indeed be related to that genus.

Nearly 1000 herbarium sheets have been used in this study. I wish to thank the curators of the various herbaria from which specimens were made available. A list of these, together with the abbreviations used for them in citing specimens is appended. In general, all specimens from the larger herbaria are cited, except those, particularly of the more common species, with incomplete data.

A—Arnold Arboretum, Harvard University, Jamaica Plain, Mass.
BG—Department of Agriculture, British Guiana.
C—University of California, Berkeley.
F—Chicago Natural History Museum (Field Museum), Chicago, Ill.
G—Gray Herbarium, Harvard University, Cambridge, Mass.
K—Royal Botanical Gardens, Kew, England.
Mich—University of Michigan, Ann Arbor.
MO—Missouri Botanical Garden, St. Louis.
NA—United States National Arboretum, Beltsville, Md.
NY—New York Botanical Garden.
P—Muséum d'Histoire Naturelle, Paris.
S—Botanical Museum of Stockholm.
US—United States National Herbarium, Washington, D. C.
V—Servicio Botanico, Ministerio de Agricultura, Caracas, Venezuela.
Herbario del Instituto Miguel Lillo, Universidad Nacional de Tucumán, Argentina.
Instituto de Botánica Darwinion, Buenos Aires, Argentina.
Jardín Botánico, Asuncion, Paraguay.
Museo Argentino de Ciencias Naturales, Buenos Aires, Argentina.

The following generic description is drawn solely from American plants, but will of course apply in large part to the genus as a whole.

Chrysophyllum L. Sp. Pl. 192. 1753.

Trees or shrubs with milky juice; leaves simple, alternate, entire or rarely toothed, glabrous or more or less hairy, often sericeous beneath, the hairs malphighiaceous, or stalked and bifurcate; venation various, most commonly with the larger secondary lateral veins trending parallel to the

primary ones, the areolae with the long axis parallel to the primary lateral veins, but sometimes irregularly reticulate, as in many species of *Pouteria*, or closely striate, as in *Micropholis*, or with prominent secondary veins at right angles to the primary ones, as in *Ecclinusa;* stipules wanting; flowers most commonly in axillary clusters, sometimes at defoliated nodes, 5-merous, or casually 4–6-merous as to sepals, petals, and stamens; sympetalous; stamens as many as the corolla-lobes and opposite them, epipetalous; staminodes wanting, or rarely a few casual and irregularly developed vestiges; ovary with 5 carpels and as many locules, or occasionally with only 4 or as many as 12 carpels and locules; ovules solitary in each locule, attached laterally or basilaterally to the axial placenta; style short, columnar, with obscurely to evidently lobed capitate stigma; fruit fleshy, often edible; seeds solitary or several, with large basilateral or long, narrow or broad lateral scar, this sometimes extending less than half way to the middle, but then very broad; endosperm well developed; embryo with thin cotyledons and well developed caudicle.

Type species: *C. cainito* L.

KEY TO THE SPECIES

1. Anthers glabrous; filaments variously attached.
   2. Filaments attached at or below the middle of the corolla-tube; seed-scar linear or linear-elliptic, not over about 4 mm. wide, except perhaps in *C. cuneifolium*, whose mature seed is unknown to me.
      3. Corolla-lobes about 0.6–0.9 mm. long, truncate, fringed-ciliolate; fruit several-seeded, about 5 cm. thick; seed-scar linear-elliptic, about 4 mm. wide. 1. *C. excelsum.*
      3. Corolla-lobes about 1.5–3 mm. long, neither truncate nor fringed ciliolate; fruit various; seed-scar, where known, narrower, seldom over 2 mm. wide.
         4. Leaves entire; filaments straight or nearly so.
            5. Primary lateral veins mostly well distinguished from the larger secondary ones, the leaf not at all striate; ovary hairy above as well as below.
               6. Flowers numerous in clusters on old wood or on defoliated portions of twigs, the pedicels, except in *C. aulacocarpum*, mostly 6–10 mm. long; secondary lateral veins, except perhaps in *C. aulococarpum* (where unknown to me), sinuous, nearly parallel, trending obliquely between or nearly at right angles to the primary ones, the tertiary veins tending to be perpendicular to the secondary ones, though sometimes obscure; Amazon basin and northward.
                  7. Flowers "subsessile"; fruit ellipsoid, 6 cm. long, 3 cm. thick, single-seeded; leaves glabrous; petioles 2–3 cm. long. 2. *C. aulacocarpum.*
                  7. Flowers on pedicels 6–10 mm. long; fruit globose to depressed-obovoid, as thick as long, several-seeded; leaves and petioles various.
                     8. Petioles about 20–35 mm. long; leaves rufous-sericeous beneath, eventually glabrate; primary lateral veins mostly 6–12 pair. 3. *C. pricurii.*
                     8. Petioles about 2–8 mm. long; leaves glabrous, or coarsely strigose on the midrib and main veins beneath; primary lateral veins mostly 12–20 pair. 4. *C. cuneifolium.*

6. Flowers 1–6 in the axils or at recently defoliated nodes, the pedicels about 5 mm. long or less; secondary and tertiary lateral veins forming an irregular reticulum; Ceara to Uruguay, northern Argentina, and southern Bolivia. 5. *C. gonocarpum.*

5. Primary lateral veins not sharply separable from the larger secondary ones, which are parallel to them, the leaf thus appearing somewhat striate, though also reticulate with evident short cross-veins; ovary densely and conspicuously pilose at the base, otherwise glabrous. 6. *C. viride.*

4. Leaves irregularly spinulose-serrate; filaments with a conspicuous double-fold near or above the middle. 7. *C. imperiale.*

2. Filaments attached at the corolla-throat; seed-scar various.

3. Corolla tubular, the lobes about one-fifth to one-half as long as the tube; Amazon drainage and northward.

4. Corolla evidently sericeous.

5. Pubescence of the young twigs and lower leaf-surfaces loosely spreading; flowers essentially sessile; Peru. 8. *C. revolutum.*

5. Pubescence strictly appresesd; flowers evidently pedicellate, though sometimes shortly so; general distribution.

6. Leaves merely rufous-strigose beneath when young, later glabrate; hairs of the corolla rufous; primary lateral veins straight or nearly so; leaves 1.5–5 cm. wide. 9. *C. nitidum.*

6. Leaves distinctly sericeous at least when young, sometimes later glabrate; leaves commonly 3.5–11 cm. wide, the primary lateral veins usually but not always more or less arcuate toward the margins.

7. Pubescence of the leaves gray or white from the first, sooner or later deciduous; pubescence of the corolla white or merely a little yellowish; northeastern Venezuela, north through the West Indies. 10. *C. argenteum.*

7. Pubescence of the leaves conspicuously yellow or rufous when young, eventually fading, sometimes finally deciduous; pubescence of the corolla rufous; generally distributed in northern South America; not in the West Indies. 11. *C. auratum.*

4. Corolla glabrous.

5. Pedicels, young twigs, and young leaves merely strigose; petioles 3–9 mm. long.

6. Pubescence rufous at first, later fading; corolla about 5–6 mm. long; Venezuela and Colombia. 12. *C. parvulum.*

6. Pubescence white, not at all rufous; corolla 4 mm. long or less; San Martin, Peru. 13. *C. albipilum.*

5. Pedicels, young twigs, and young leaves evidently spreading-hairy, the hairs rufous; petioles 2–3 mm. long; Acre Territory and adjacent Amazonas, Brazil. 14. *C. acreanum.*

3. Corolla campanulate to subrotate, the lobes mostly equaling or exceeding the tube (barely shorter in *C. pavonii;* also shorter in *C. dusenii,* but even then more than half as long as the tube, and the creases extending farther down on the outside); general distribution.

4. Petioles about 2–3.5 cm. long; secondary lateral veins conspicuous, somewhat sinuous, trending obliquely between or at right angles to the primary ones, and sharply distinguished from them; tertiary lateral veins mostly perpendicular to the secondary ones, or obscure. 3. *C. prieurii.*

4. Petioles about 1 cm. long or less; venation various, but not as above.
5. Leaves closely and conspicuously striate, the veins averaging about 0.5 mm. apart; northern Peru. 15. *C. granatense.*
5. Leaves weakly, scarcely, or not at all striate, the veins only 1–2 mm. apart in *C. marginatum*, more distant in the other species.
6. Leaves loosely hairy or nearly glabrous at flowering time, not at all sericeous.
7. Corolla about 3.5–5 mm. long, the lobes distinctly shorter than the tube, as measured from the inside; creases for the corolla-lobes extending about 0.4–0.8 mm. farther on the outside than on the inside, because the lobes are joined within by a thin cylinder of tissue; pedicels 5–11 mm. long. 16. *C. dusenii.*
7. Corolla about 1.7–3.0 mm. long, the lobes equaling or exceeding the tube, about the same length inside as out; pedicels up to 4 mm. or rarely 6 mm. long.
8. Seed-scar basilateral, broad, extending two-thirds the length of the seed, or usually less; primary lateral veins rather weak, straight or nearly so, either crowded and only 1–2 mm. apart, making the leaf appear weakly striate, or more distant but with the secondary veins weak and mostly trending parallel to them.
9. Fruit 5–10 (rarely 13) mm. long; seed-scar scarcely extending to the middle of the seed; leaves tending to be weakly striate, varying from rounded or even retuse to acute at the apex, not acuminate. 17. *C. marginatum.*
9. Fruit about 15–20 mm. long; seed-scar about two-thirds as long as the seed; leaves acuminate, not at all striate. 18. *C. ovale.*
8. Seed-scar linear, lateral, extending the length of the seed; primary lateral veins strong, not at all crowded, the leaf not striate; secondary lateral veins forming a coarse and conspicuous irregular reticulum. 19. *C. lucentifolium.*
6. Leaves sericeous or sericeous-tomentose beneath with appressed reddish hairs at flowering time, sometimes eventually glabrate.
7. Stigma evidently 7–12-lobed; pedicels about 5–15 mm. long; fruit 3 cm. thick or generally more, several-seeded; seed-scar lateral, extending nearly the whole length of the seed, very broad; Colombia to Surinam, and northward. 20. *C. cainito.*
7. Stigma obscurely 5–7-lobed; pedicels about 1–3 mm. long; fruit, where known, smaller, less than 2 cm. thick; seeds, where known, with basilateral scar extending only to the middle.
8. Corolla-lobes about twice as long as the tube, or longer; filaments slender, flexuous or variously contorted; French Guiana and eastern Brazil.
9. Primary lateral veins arcuate; secondary lateral veins loosely reticulate, the stronger ones mostly trending at right angles to the primary veins; leaves broadest above the middle; fruit and seed unknown; French Guiana. 21. *C. cochlearium.*

9. Primary lateral veins straight, bifurcate near the margins; secondary lateral veins trending nearly parallel to the primary ones, the larger ones not always sharply separable from them; leaves broadest about at or below the middle; Ceara and Bahia, Brazil. 22. *C. rufum.*

8. Corolla-lobes scarcely equaling the tube; filaments stout, straight; Peru. 23. *C. pavonii.*

1. Anthers villous; filaments attached about at the middle of the corolla-tube, or lower.

2. Leaves spreading-hairy beneath. 24. *C. januariense.*

2. Leaves appressed-hairy or glabrous beneath.

3. Pedicels about 2–3 mm. long; filaments free from the corolla-tube, or nearly so; British Guiana, and Para, Brazil. 25. *C. sparsiflorum.*

3. Pedicels about 5–25 mm. long, except in *C. arenarium;* filaments distinctly attached to the corolla-tube; eastern and southern Brazil, not in the Amazon basin.

4. Leaves permanently and densely sericeous or sericeous-tomentose beneath with strongly rufous hairs.

5. Pubescence rich purplish red; pedicels 15–25 mm. long; leaves about 4–11 cm. long. 26. *C. pulcherrimum.*

5. Pubescence merely coppery-rufous; pedicels about 7–13 mm. long; leaves about 10–30 cm. long. 27. *C. splendens.*

4. Leaves glabrous or finely strigose or sericeous-strigose with whitish hairs beneath, at flowering time, sooner or later glabrate.

5. Leaves about 1.5–6 cm. long, the secondary lateral veins obscure; pubescence of the pedicels and young leaves strongly rufous; pedicels about 2–6 mm. long; corolla only about 2 mm. long. 28. *C. arenarium.*

5. Leaves about 4–40 cm. long, the secondary lateral veins evident; pubescence of the leaves and pedicels white or yellowish, rarely a little rufous in *C. flexuosum;* pedicels about 5–16 mm. long; corolla about 3–7 mm. long.

6. Secondary lateral veins mostly parallel to the primary ones and not sharply separable from them, the lateral veins thus appearing crowded, about 1–3 mm. apart; hairs of the lower leaf-surfaces very short and closely appressed, about 0.1–0.3 mm. long. 29. *C. inornatum.*

6. Secondary lateral veins mostly few and loosely reticulate, the primary ones more widely spaced and readily identifiable, about 5–15 mm. apart; hairs longer and merely loosely appressed, about 0.3–0.6 mm. long. 30. *C. flexuosum.*

1. CHRYSOPHYLLUM EXCELSUM Huber, Bol. Mus. Pará **3**: 55. 1902.

Rather large tree; terminal bud sericeous-tomentose with rufous hairs, the leaves probably similarly hairy at first, but very soon glabrate, the blade elliptic or elliptic-obovate, 10–30 cm. long and 5–12 cm. wide, rounded to acutish at the apex; primary lateral veins well-spaced, arcuate; secondary veins fairly regular, becoming perpendicular to the primary ones near the margin; tertiary veins forming a more or less evident reticulum; petioles about 2–4 cm. long; flowers in clusters of about 3–10 at defoliated nodes or in the axils, the pedicels strigose, about 5 mm. long; sepals reniform-orbicular, sericeous-strigose, about 2.9–3.3 mm. long; corolla about 3.8–4.3 mm. long, the lobes broadly oblong, subtruncate, fringed-ciliolate, about 0.6–0.9 mm. long, the creases showing a little farther down the tube on the outside;

filaments attached at or below the middle of the tube, their traces commonly visible to the base; anthers mucronate, about 0.8 mm. long; ovary densely pilose; style glabrous, tapering-columnar, about 2.5 mm. long, nearly lobeless; fruit globose, yellow, about 5 cm. thick; seeds 5 or sometimes fewer, ovate-oblong, about 25 mm. long, 14 mm. wide, and 7 mm. thick, the scar linear-elliptic, about 4 mm. wide, extending nearly the whole length of the seed.

TYPE: Specimens collected from a cultivated tree in Pará, Brazil.

Local names: Sorba do Perú, guajará.

Distribution: Upper Amazon basin, Brazil, to northern Venezuela; presumably also in Peru.

BRAZIL: Pará: *Ducke 602*, Belém do Pará (cult.) (MO, US); *Ducke 15802*, Belém do Pará (cult.) (K, S, US); *Huber 3016*, Belém do Pará (cult.) (US.). Amazonas: *Kuhlmann 21991*, Altamira (NY, US). VENEZUELA: Federal District: *Pittier 13500*, El Limón (F, US).

2. CHRYSOPHYLLUM AULACOCARPUM Ernst, Flora **57**: 214. 1874.

Tree; young twigs slightly rufous-hairy; leaves crowded at the ends of the branches, glabrous, oblong-oval to obovate-oblong, tapering from the middle to the base, about 16–24 cm. long and 9–11 cm. wide; primary lateral veins about 11–14 pair; secondary veins reticulate; petioles about 2–3 cm. long; flowers numerous in clusters at defoliated nodes, subsessile and glomerate; calyx and corolla 4–5-lobed, rufous-sericeous, the corolla about 6–7 mm. across; filaments inserted on the corolla-tube; ovary conic, pentagonal, 5-locular; style short, glabrous; stigma-lobes obscure; fruit ellipsoid, about 6 cm. long and 3 cm. thick, edible, single-seeded; seed ovoid, blackish, shining, about 3 cm. long; seed-scar linear, extending from the base to the apex.

TYPE: *Fermin Toro s.n.*, Los Teques, Venezuela.

Local name: Chupon.

Distribution: Known only from the type collection, Los Teques, Miranda, Venezuela.

The description for this species is taken from the original; I have seen no specimens. It is conceivable that it is conspecific with the later *C. excelsum* Huber, but it seems likely that if it had the characteristic short, truncate, fringed-ciliolate corolla-lobes of that species, that feature would have been noted by Ernst, who gave a fairly complete description. The difference in shape and number of seeds of the fruit, although yet to be proved constant, also suggests that this species is distinct. It should be noted that the *Pittier* collection of *C. excelsum* from Venezuela was taken not far from the type locality of *C. aulacocarpum*. The herbarium specimens are sterile, but bear the collector's note, fruit apple-shaped, yellow. Until further evidence is available, I prefer to retain both names.

3. CHRYSOPHYLLUM PRIEURII A. DC. Prodr. **8**: 161. 1844.

C. cyanogenum Ducke, Trop. Woods **71**: 18. 1942.

Large tree sometimes 45 m. tall, pervaded with hydrocyanic acid; twigs coarse, sericeous, the hairs at first rufous, soon fading; leaves clustered

toward the ends of the twigs, obovate, rounded to abruptly short-acuminate, about 10–17 cm. long and 5–8 cm. wide, glabrous above, finely and closely rufous-sericeous beneath, but the hairs eventually deciduous and sometimes fading before falling; primary lateral veins mostly 6–12 pair, well-spaced, arcuate; secondary lateral veins somewhat sinuous, nearly parallel and extending obliquely between or nearly at right angles to the primary veins; tertiary lateral veins perpendicular to the secondary ones, or obscure; petioles 2–3.5 cm. long; flowers numerous in dense clusters on the twigs below the leaves, the pedicels rufous-sericeous, 6–10 mm. long, elongating in fruit; sepals rufous-sericeous like the pedicels, rounded, the inner conspicuously fringed-ciliolate, about 2–3 mm. long; corolla about 3.4–4.2 mm. long, glabrous, the lobes reputedly equaling the tube, but in specimens available to me about 3–4 times as long as the tube; filaments reputedly inserted at the middle of the tube, but in specimens available to me inserted at the level of the sinuses, or the stamens sometimes abortive; ovary 5-locular, pubescent with short sub-appressed rufous hairs; style about 0.7 mm. long, hairy below; stigma-lobes 5; fruit yellow, spherical, 3–5 cm. thick, several-seeded, reputedly edible; seeds 15–30 mm. long, 10–15 mm. wide, and 4–7 mm. thick, with a linear scar extending nearly to the summit; endosperm copious.

TYPE: *LePrieur 157*, Cayenne, French Guiana (NY—photo).

Local names: Palo de cuyure (Venezuela); Caran (Colombia); Abiurana (Amazonas, Brazil).

Distribution: French Guiana to Colombia and Amazonas, Brazil.

COLOMBIA: Boyaca: *Lawrence 820*, 130 miles north of Bogotá (K). VENEZUELA: Amazonas: *Willams 14550*, San Carlos de Río Negro (US). SURINAM: *B.W. 3792*, Gonini River (K), *3794* (US). FRENCH GUIANA: *Melinon s.n.* (F, K, P, US); *Melinon 118*, Maroni (K). BRAZIL: Amazonas: *Ducke 813*, Manaos (MO); *Froes 12*, Manaos (Herb. B. A. Krukoff).

The only flowers of this species available to me for dissection were from an isotype of *C. cyanogenum* Ducke, and these differ in certain particulars, as noted above, from Ducke's description. My description of the fruit is taken from that given by Ducke.

4. CHRYSOPHYLLUM CUNEIFOLIUM (Rudge) A. DC. Prodr. **8**: 160. 1844.

Bumelia cuneifolia Rudge, Pl. Gui. **1**: 30. *pl. 47*. 1805.

Tree; leaves cuneate-oblanceolate, mostly abruptly acuminate, tapering gradually to the base, about 10–25 cm. long and 3.5–8 cm. wide, glabrous, or coarsely strigose on the midrib and main veins beneath, subsessile, the petioles only 2–8 mm. long; primary lateral veins well spaced, arching near the margins, about 12–20 pair; secondary lateral veins fairly regular and nearly parallel, somewhat sinuous, trending nearly at right angles to the primary ones; tertiary veins tending to be perpendicular to the secondary ones; flowers numerous in clusters on old wood, the pedicels about 1 cm. long; sepals about 2.0–2.7 mm. long, conspicuously fringed-ciliate, especially the inner; corolla about 4 mm. long, the lobes three times as long as the tube; filaments attached near the base of the corolla-tube, or half-way up to the sinuses; ovary shortly appressed-hairy; style about 0.5 mm. long; stigma-lobes 5; fruit several-seeded, narrowly sulcate between the seeds, up to 4 cm. long or perhaps more, obovoid or depressed-obovoid.

TYPE: Plants collected in French Guiana (near Cayenne, according to Alphonse DeCandolle), by an unspecified collector, presumably now deposited at the British Museum.

Distribution: French and Dutch Guiana.

SURINAM: *B.W. 1505* (K, US), *1586* (K), *2033* (K), *3939* (K, S), *4384* (US), *5479* (S, US); *Von Hall 89a* (K, Mich, S, US).

5. CHRYSOPHYLLUM GONOCARPUM (Mart. & Eichl.) Engl. Bot. Jahrb. **12**: 523. 1890.

Sapota gonocarpa Mart. & Eichl. ex Miq. in Mart. Fl. Bras. **7**: 60. 1863.

Chrysophyllum cysneiri Freire-Allem. Trab. Comm. Sci. Expl. Bras. Bot. 66. *pl. 18.* 1866.

C. ecarense Freire-Allem. op. cit. 72. *pl. 21.*

C. obtusifolium Freire-Allem. op. cit. 74. *pl. 23.*

C. persicastrum Eichl. Kjoeb. Vidensk. Meddel. **1870**: 208. 1871.

C. lucumifolium Griseb. Goett. Abh. **24**: 223. 1879.

Sideroxylon reticulatum Britton, Ann. N. Y. Acad. Sci. **7**: 156. 1893.

Chrysophyllum lucumifolium f. obtusatum Chod. & Hass. Bull. Herb. Boiss. II. **7**: 675. 1907.

Sideroxylon bolivianum Rusby, Mem. N. Y. Bot. Gard. **7**: 319. 1927.

Small tree about 4–12 m. tall; leaves rather loosely sericeous-tomentose with white or slightly rufous hairs when young, soon glabrate, elliptic-oblanceolate to occasionally narrowly elliptic or narrowly obovate, broadly obtuse or rounded to occasionally acutish at the apex, mostly 7–18 cm. long and 2–6 cm. wide, often some of them smaller; venation pouterioid, with raised, arching primary lateral veins and a well-developed rather irregular raised reticulum of secondary and tertiary lateral veins; petioles up to about 2 cm. long; flowers about 1–6 in the axils or at recently defoliated nodes, subsessile or on pedicels up to about 5 mm. long, perfect or reputedly sometimes unisexual; sepals thin, light green, rounded, finely sericeous-strigose or subglabrous, about 2.2–3.3 mm. long; corolla about 3.2–3.8 mm. long, the lobes 1.5–2.1 mm.; anthers about 1.1–1.3 mm. long; filaments attached at the base of the corolla-tube, or occasionally joined to it part way up; ovary very densely pilose, the style glabrous, about 1.7–2.0 mm. long, lobeless; fruit yellow, with rather thin sweet edible pulp, 1–5-seeded, sulcate between the seeds, mostly 12–25 mm. (rarely 40 mm.) long; seeds compressed, obliquely obovate, about 10–18 (rarely 30) mm. long; seed-scar linear, about 1–2 mm. wide, extending nearly the whole length of the seed.

TYPE: *Th. Peckolt s.n.*, "prope Canta Gallo, prov. Rio de Janeiro," Brazil.

Local names: Aguay, aguaja (Argentina and Paraguay); Oito bravo (Ceara); Peroba blanco (Rio de Janeiro); Pecigo do mato (Minas Geraes).

Distribution: Ceara, Brazil, southwest to Paraguay, Uruguay, northern Argentina, and southern Bolivia.

BRAZIL: Minas Geraes: *Glaziou 19610* (K); *Regnell 1599*, near Caldas (K); *Warming s.n.* (NY); *Widgren s.n.* (S). Rio de Janeiro: *Glaziou 11143* (K), *11144* (C—photo, G—photo, K, NY—photo). Sao Paulo: *Mosen 3956*, inter Campinas et Vallinhos (S); *Mosen 4241* (S); *Regnell 1599* (S, US). Paraná: *Dusén 10741* (S), *11160* (S); *Dusén 11251*, Theresina (S); *Dusén 17099* (S); *Dusén 17873*, Rio Capinqual (S). Santa Catharina: *Dusén 11819*, Rio Uruguay (S). Rio Grande do Sul: *Leite 1954* (G); *Malme 856*, Porto Alegro (S). BOLIVIA: La Paz: *Rusby 691*, near Huachi, head of Beni River (NY); *Steinbach 7249*, Sara, Río Surutu (S). PARAGUAY: *Balansa 2389* (K), *2391* (K), *4649*

(F); *Fiebrig 458* (A, F, K), *4284* (G, K); *Hassler 3759* (S), *3628* (F, K), *7772* (A, F, K), *11516* (A), *12382* (A, G, MO, K, US); *Jorgensen 3759* (A, G, MO), *3762* (F, G. PA, US); *Lindman A1703*, Asuncion (S); *Malme 994B*, near Rio Apa (S); *Morong 839* (F, K, NY); *Osten 9084*, San Bernardino (S). URUGUAY: *Herter 1606* (C, F, G, MO); *Lorentz 299* (G—photo, NY—photo); *Osten 17998* (US). ARGENTINA: Salta: *Eyerdam & Beetle 22742* (C, G, MO), *22781* (C, G, MO); *Lorentz & Hieronymus 525* (K, NY, S); *Rodriguez 1024* (F, NY); *Schreiter 11496* (Cl, G, NY); *Venturi 5567* (A, C, MO, K, S, US), *7983* (US). Chaco: *Jorgensen 2149* (G, MO). Misiones: *Rodriguez 373* (G, US).

6. CHRYSOPHYLLUM VIRIDE Mart. & Eichl. ex Miq. in Mart. Fl. Bras. **7**: 102. 1863.

Fibrocentrum glaziovianum Pierre, Mém. Bot. Soc. Fr. 3: 441. 1910. Hyponym.
?Chrysophyllum perfidum Freire-Allem. Trab. Comm. Sci. Expl. Bot. Rio de Janeiro 1: 68. 1866.

Large tree; leaves oblanceolate or narrowly elliptic, commonly abruptly short-acuminate, sometimes merely acutish or even rounded, about 5–11 cm. long and 15–40 mm. wide, strigose or sericeous-strigose when young, glabrate at maturity, borne on petioles up to 1.5 cm. long; primary lateral veins generally more than 20 pair, not sharply separable from the larger secondary veins, which are parallel to them, the leaf thus appearing striate, but also reticulate with evident cross-veins; flowers several in the axils or at recently defoliated nodes, the pedicels strigose or subglabrous, 4–10 mm. long; sepals rotund, slightly strigose, about 1.7–2.5 mm. long; corolla about 3.0–3.4 mm. long, the lobes a little longer than the tube, reniform-ovate, the tube moderately yellowish-sericeous; filaments attached at or below the middle of the tube, the anthers about 1.1–1.2 mm. long, or in some flowers the anthers wanting and the filaments minute; ovary densely and conspicuously pilose at the base, otherwise glabrous, the style short or obsolete; ovules 5, or in some flowers the ovary more slender or reduced and the ovules wanting; perfect flowers not seen by me, but reputed to exist; fruit ellipsoid-globose, yellow, edible, about 1.5–2.5 cm. thick and up to 4 cm. long; seeds 1–3, somewhat compressed, about 1 cm. wide and 1.5–3 cm. long; seed-scar linear, less than 2 mm. wide, extending the length of the seed; endosperm well developed; embryo with thin cotyledons and evident caudicle.

TYPE: *Schüch s.n.*, eastern Brazil (NY—photo).

Distribution: Rio de Janeiro, Santa Catharina, and Paraná, Brazil, possibly extending as far north as Ceara.

BRAZIL: Rio de Janeiro: *Glaziou 18354* (G—photo, NY). Santa Catharina: *Reitz C–330* (G). Paraná: *Dusén 11994*, Volta Grande (S), *12130*, Desvio Ypiranga (S), *17343*, Tacarehý (S).

Chrysophyllum perfidum Freire-Allem., from Ceara, is probably conspecific with *C. viride*, but differs, according to the original description and figure, in its depressed-globose rather than ellipsoid-globose fruit, with a pronounced areola at the tip, and in its thicker cotyledons and rather scanty endosperm. Allemao reports that it is locally known as goerana.

7. CHRYSOPHYLLUM IMPERIALE (Linden) Benth. & Hook. Gen. Pl. **2**: 653. 1876.

Theophrasta imperialis Linden ex Koch & Fint. Wochenschr. 2: 91. 1859.
Martiusiella imperialis Pierre, Not. Bot. Sapot. 66. 1891.

Small tree with very coarse twigs; leaves cuneate-oblanceolate, obtuse, rounded at the base, irregularly spinulose-serrate, about 15–75 cm. long and 5–25 cm. wide in specimens seen, but reputedly up to a meter or more long, loosely grayish-hirsutulous beneath when young, later glabrate, firm, the midrib coarse and strongly raised beneath; primary lateral veins about 20–50 pair, strongly raised beneath, arcuate toward the margins; secondary and tertiary lateral veins forming a coarse and irregular reticulum, or the secondary veins sometimes perpendicular to the primary ones; petioles about 2–2.5 cm. long; flowers several or numerous in the axils or at defoliated nodes, the pedicels closely hairy, about 5–6 mm. long; sepals rounded, sericeous-tomentose, about 3–4 mm. long; corolla about 4–4.5 mm. long, the rounded-ovate lobes rufous-strigose, equaling or a little exceeding the glabrous tube; minute staminodes sometimes irregularly developed; filaments attached near the base of the corolla-tube, with a conspicuous and persistent double fold near or above the middle; anthers about 1.1–1.5 mm. long; ovary 5-locular, short-hairy, tapering to the summit, the style obsolete, the stigma-lobes obscure; fruit several-seeded, broadly ovoid or subglobose, about 2.5–3.5 cm. long and nearly or quite as thick, tapering to the apex; seeds strongly compressed, about 18–25 mm. long, 13–16 mm. wide, and 6–9 mm. thick; seed-scar linear, 2 mm. wide or less, extending the length of the seed; endosperm copious; embryo with thin cotyledons and well-developed caudicle.

TYPE: Specimens raised from seeds brought from Brazil by Linden.

Local name: Marmelleiro do matto.

Distribution: Rio de Janeiro, Brazil.

BRAZIL: Rio de Janeiro: *Glaziou 8230* (A, F, K, S), *6633*, Serra do Estrello (K), *11163* (K), *7745* (K), *20402* (K).

The double bend in the filaments of *Chrysophyllum imperiale* is reminiscent of *Pradosia*, but in that genus the folded portion is distal and abruptly tenuous, and straightens out as the flower matures, while in *C. imperiale* the fold is near or a little above the middle, and persistent, and the filament is of about the same texture throughout.

8. CHRYSOPHYLLUM REVOLUTUM Mart. & Eichl. ex Miq. in Mart. Fl. Bras. 7: 104. 1863.

Young twigs densely pubescent with loose short rufous hairs; leaves firm, with revolute margins, elliptic-oblong, 4–9 mm. long, 1.5–4.5 cm. wide, loosely rufous-hirsute on both sides when young, soon glabrate above, and perhaps eventually so beneath; primary lateral veins about 12–15 pair, rather irregularly spaced, bifurcate or arcuate toward the margins; secondary lateral veins few and mostly obscure, trending parallel to the primary ones; petioles about 3–4 mm. long; flowers clustered in the axils or at recently defoliated nodes, essentially sessile; sepals thick and firm, ovate, acute, rufous-hairy, about 1.5 mm. long; corolla about 5 mm. long, densely rufous-sericeous except near the base and at the tips of the lobes, the lobes about one-fourth as long as the tube; filaments short, attached at the level of the sinuses; anthers 0.4–0.5 mm. long; ovary densely rufous-hairy, 5-locular, the style glabrous, about 0.5 mm. long; fruit blackish, insipid, subsessile, ellipsoid-globose, about 12 mm. long, single-seeded; seed-scar basilateral, very broad, extending about two thirds of the way to the top.

TYPE: *Spruce 4260*, "prope Tarapota, Peruvia orientalis," 1855 (F, G, K).

Distribution: Known only from the type locality, in Loreto, Peru.

PERU: Loreto: *Ule 6616*, near Tarapoto, *1902* (K).

9. CHRYSOPHYLLUM NITIDUM G. F. W. Mey. Prim. Fl. Esseq. 116. 1818.

C. psilophyllum A. DC. Prodr. 8: 160. 1844.

Large tree; young twigs slender, rufous-strigose or -sericeous; leaves elliptic or elliptic-lanceolate, acuminate, about 5–12 cm. long and 1.5–5 cm. wide, glabrous and shining above, rufous-strigose beneath when young, later glabrate; primary lateral veins straight or slightly curved, rather weak, about 8–13 pair; secondary lateral veins few, mostly trending parallel to the primary ones; petioles about 5–9 mm. long; flowers several in the axils, the pedicels rufous-sericeous, about 2–6 mm. long; sepals rounded, rufous-sericeous, about 1.3–1.5 mm. long; corolla about 4–5.5 mm. long, the lobes about one-third to one-fifth as long as the rufous-sericeous tube; filaments minute, attached at the level of the sinuses; anthers about 0.4 mm. long; ovary 5-locular, appressed-hairy, tapering to the glabrous style which is less than 1 mm. long; fruit unknown.

TYPE: None given, but stated to grow "in sylvis continentis," presumably near the mouth of the Essequibo River, in British Guiana.

Local name: Kokeritiballi (British Guiana).

Distribution: French Guiana to Colombia.

COLOMBIA: *Mutis 1125* (US). BRITISH GUIANA: *"D." 160*, Simuni Creek, Rupurruni River (BG); *Fanshawe 2021*, Mazaruni River (NY). FRENCH GUIANA: *Martin 255* (F, G, K, NY, US); *Poiteau s.n.* (F); *Sagot 845* (F, K, P, S).

10. CHRYSOPHYLLUM ARGENTEUM Jacq. Enum. Pl. Carib. 15. 1760.

C. glabrum Jacq. Enum. Pl. Carib. 15. 1760.
C. caeruleum Jacq. Stirp. Select. Am. 52. ca. 1780.
C. immersum Urb. Rep. Sp. Nov. 15: 414. 1919.

Tree or shrub, sometimes as much as 30 m. tall; leaves elliptic to oblong-elliptic or occasionally ovate, of various sizes up to about 20 cm. long and 8 cm. wide, rounded to acutish or abruptly acuminate at the apex, glabrous above, thinly sericeous at first with whitish hairs beneath, sooner or later glabrate; primary lateral veins well-spaced, usually arcuate toward the margins; secondary lateral veins generally trending about parallel to the primary ones, the long axis of the areolae parallel to the primary veins; flowers clustered in the axils or at recently defoliated nodes, the pedicels mostly 4–13 mm. long; sepals about 1.5–2.5 mm. long, sericeous with fine pale or slightly reddish hairs; corolla about 4–6 mm. long, sericeous to near the base with fine white or somewhat yellowish hairs, the tips and margins of the lobes smooth, the lobes about one-third to one-half as long as the tube; filaments inserted at the level of the sinuses, with more or less evident traces; anthers 0.4–0.8 mm. long; stigma with 5–9 evident to obscure lobes; fruit dark red or purple to blue or nearly black, ellipsoid or occasionally subglobose, mostly 1.5–2 cm. long, occasionally only 1 cm. long, single-seeded; seed-scar basilateral, broad, commonly extending to near the middle.

TYPE: None given; from Martinique, according to Index Kewensis.

Distribution: General throughout the West Indies from Oriente, Cuba, to Trinidad, and in Sucre, Venezuela.

TRINIDAD: *Britton & Britton 2217* (G, NY, US); *Dannouse 8317*, (NY); *Hart 5437* (S); *Sieber 371* (MO). TOBAGO: *Broadway 3991* (A, G, MO, NY, S, US), *4411* (NY, US); *Sandwith 1881* (NY). VENEZUELA: Sucre: *Broadway 495*, near Cristobal Colón (G, K, NY, US); *Broadway 714*, near Cristobal Colón (G, NY, US).

11. CHRYSOPHYLLUM AURATUM Miq. in Mart. Fl. Bras. **7**: 97. 1863.

C. sericeum A. DC. Prodr. **8**: 158. 1844; not Salisb. 1796.
C. auratum var. *majus* Miq. in Mart. Fl. Bras. **7**: 98. 1863.

Shrub or tree sometimes as much as 35 m. tall; leaves elliptic, elliptic-oblong, or elliptic-obovate, about 7–23 cm. long and 3.5–11 cm. wide, rounded or abruptly acuminate at the apex, glabrous above, closely sericeous beneath with a shining sometimes eventually deciduous rufous pubescence that turns pale in age; primary lateral veins mostly well-spaced and arching; secondary lateral veins few, scarcely or not at all visible above, not very prominent beneath; petioles about 6–15 mm. long; flowers clustered in the axils or at recently defoliated nodes, the pedicels about 2–7 mm. long; sepals about 1.2–2.0 mm. long, rufous-strigose, rather firm; corolla tubular, about 3.2–6.5 mm. long, rufous-sericeous outside, at least above, the lobes one-fourth to one-half as long as the tube; ovary appressed-hairy; stigma-lobes mostly 5–6, sometimes as many as 10; fruit purple, ellipsoid, about 1.5–2 cm. long; seed-solitary, with broad basilateral obcordate scar extending to about the middle; cotyledons somewhat thickened and a little fleshy, each about as thick as the endosperm.

TYPE: The first specimen cited is *Schomburgk 864*, from "Roraima," British Guiana (F, G, K, NY). *Schomburgk 1389*, from the banks of the Pomeroon River, British Guiana (K), is also cited.

Local names: Sürübüruen, wild star-apple (British Guiana); Maparajuba, rozada brava (Amazonas, Brazil).

Distribution: French Guiana, and northern Amazonas and Para, Brazil, to Colombia, south to Ecuador and Peru.

COLOMBIA: *Mutis 1100* (US), *4030* (F, US), *5831* (US). Bogotá: *Triana s.n.*, près de La Mesa (K). Norte de Santander: *Killip & Smith 20536*, Culaga Valley (G, US). VENEZUELA: *Gollmer s.n.* (G—photo, NY—photo). Merida: *Pittier 12751* (NY, US). Portuguesa: *Pittier 12079*, between Aspini and Aprición (US). Aragua: *Williams 11074* (A, F, US). Sucre: *Broadway 154*, near Cristobal Colón (G, NY, US). BRITISH GUIANA: *Anderson 6*, Aruka River (K); *De La Cruz 3300*, Kabakaburi, Pomeroon District (C, F, G, MO, NY, PA); *De La Cruz 4138*, Kamakusa, upper Mazaruni River, (F, G, MO, NY, PA, US); *Fanshawe 565*, Moraballi Creek (BG); *Fanshawe 2446*, Yarikita Creek, Aruka River (BG); *Hitchcock 17659*, Yaritka and Amakura Rivers (G, NY, S, US); *Hohenkirk 9*, Waini Creek (K); *Sandwith 338*, Essequibo River, near Bartica (K, NY); *Sandwith 678*, Cuyuni River (K); *Schomburgk 550/856* (K), *813* (K), *1507* (K); *Tutin 354*, Cuyuni River (K, US). SURINAM: *B.W. 3327*, Watramiri (K, US), *3873*, Watramiri (K), *4547*, Watramiri (G. K, S, US); *Hostmann 630* (F, K); *Hostmann & Kappler 630B* (S), *1139* (K, MO, S); *Lanjouw 808*, Coppename River, near Raleighfalls (K, Mich, S, US). FRENCH GUIANA: *Gabriel s.n.* (F, G—photo); *Martin s.n.*, Cayenne (K). BRAZIL: *Riedel 1419*, Amazon River (US). Pará: *Ducke 12128*, Rio Branco de Obidos (US); *Ducke 14834*, Obidos (US). Amazonas: *Froes 65*, Esperanza, basin of Rio Solimoes (Herb. Krukoff); *Froes 3232*, Sao Paulo de Olivenca, basin of Rio Solimoes (Herb. Krukoff); *Froes 102*, Esperança, basin of Rio Javary (Herb. Krukoff.) ECUADOR: *Eggers 15450*

(F); *Popenoe 1308*, Portovelo (US); *Popenoe 1349*, Est. Exp. Chobo (US). PERU: San Martin: *Klug 3843*, Juan Jui, Alto Rio Huallaga (F, G, MO, NY, S, US). Loreto: *Williams 3945*, Lower Río Huallaga (F, S, US); *Klug 1318*, near Iquitos (F, US).

12. CHRYSOPHYLLUM PARVULUM Pitt. Contr. Fl. Venez. 42. 1923.

Arborescent shrub or small tree about 4 m. tall, the twigs slender, loosely rufous-strigose when young; leaves elliptic or elliptic-oblong to elliptic-ovate, acute or acuminate, about 4–8 cm. long and 2–4 cm. wide, rufous-strigose beneath when young, the hairs later fading and eventually deciduous; primary lateral veins weak, straight or nearly so, neither crowded nor very distant, not always sharply separable from the larger secondary veins, which trend parallel to them; petioles about 4–9 mm. long; flowers 2–6 in the axils, the pedicels densely rufous-sericeous, about 2 mm. long; sepals about 1.6–2.0 mm. long, rounded, sparsely rufous-strigose; corolla glabrous, 5–6 mm. long, the tube about 2–3 times as long as the rounded lobes; filaments very short, attached at the level of the sinuses; anthers about 0.6–0.7 mm. long; ovary 5-locular, rufous-hairy, tapering above to the conic glabrous style; stigma 5-lobed; fruit ellipsoid, 2.5–3 cm. long, 15–17 mm. thick; seed solitary, about 13–15 mm. long, with a broad obovate scar nearly as long; embryo somewhat thickened, the endosperm relatively thin.

TYPE: *Pittier 9093*, "Selvas do Guaremales, 50 m., cerca de Urama," October 3, 1920 (G, NY, US, V).

Local name: Pascualita.

Distribution: Venezuela and Colombia.

VENEZUELA: *Delgado 212* (US, V). COLOMBIA: *Karsten s.n.*, in 1890 (F—photo & fragment, G—photo, NY—photo).

13. **Chrysophyllum albipilum** Cronquist, sp. nov.

Tree about 7 m. tall; young twigs slender, white-strigose; leaves elliptic or elliptic-obovate, obtuse or acute, about 4–11 cm. long and 2–4.5 cm. wide, white-strigose beneath when young, later glabrate; primary lateral veins about 7–10 pair, straight, or more commonly arcuate near the margins; secondary lateral veins rather irregular, forming a very loose reticulum; petioles about 3–6 mm. long; flowers clustered in the axils, the pedicels gray-sericeous, about 2 mm. long; sepals hairy like the pedicels, the outer acute or acutish, the inner more rounded, about 1.5–1.8 mm. long; corolla green, about 3.7–4.1 mm. long, glabrous, the tube about twice as long as the rounded lobes; filaments short, attached at the level of the sinuses, their traces visible to the base; anthers about 0.5–0.6 mm. long; ovary 4–5-locular, short-hairy, rather abruptly contracted to the thick glabrous 1 mm. style; stigma-lobes 4–5; fruit unknown.

Arbor 7 m. alta, ramulis albo-strigosis glabrescentibus, foliis ellipticis vel elliptico-ovatis, obtusis vel acutis, ca. 4–11 cm. longis 2–4.5 cm. latis, infra albo-strigosis glabdescentibus, venis 7–10-jugis, venuils laxe et irregulariter reticulatis; flores axillares pedicellis 2 mm. longis, sepalis 1.5–1.8 mm. longis griseisericeis, corolla glabra 3.7–4.1 mm. longa lobis ½ tubum aequantibus, filamentis fauce affixis, ovario 4–5-loculare stylo glabro; fructus ignotus.

TYPE: *Klug 4365*, forest, Juan Jui, Alto Rio Huallago, 400–800 m., San Martin, Peru, May, 1936 (US); isotypes at A, F, K.

Distribution: Known only from the type collection, San Martin, Peru.

This species is obviously related to *C. parvulum*, from which it differs in its white, not at all rufous-tinted pubescence, less regular more reticulate leaf-venation, smaller flowers, and disjunct distribution.

14. CHRYSOPHYLLUM ACREANUM A. C. Smith, Brittonia **2**: 161. 1936.

Arborescent shrub or tree up to 12 m. tall, with slender twigs; young twigs, young leaves, petioles, and pedicels conspicuously pubescent with short spreading rufous hairs; leaves elliptic or lance-elliptic, mostly acuminate, about 3–13 cm. long and 1–4 cm. wide, soon glabrous, except along the midrib beneath, where more tardily so; primary lateral veins about 8–18 pair, rather irregularly set, straight, bifurcate near the margins; secondary veins few, trending parallel to the primary ones, and not always sharply separable from them; petioles about 2–3 mm. long; flowers several in axillary clusters, the pedicels about 3–4 mm. long; corolla glabrous, about 3.8–4.4 mm. long, the lobes about one-third to one-half as long as the tube; filaments very short, inserted at the level of the sinuses, or a little above; anthers about 0.4–0.6 mm. long; ovary 5-celled, hairy, with a short glabrous style; stigma-lobes 5; fruit unknown.

TYPE: *Krukoff 5593*, on terra firma, near mouth of Rio Macauhan, basin of Rio Purus, 9 degrees 20 minutes South, 69 degrees West, Acre Territory, Brazil, August 21, 1933 (A, C, MO, NY, US).

Distribution: Acre Territory, Brazil, and adjacent parts of Amazonas.

BRAZIL: Amazonas: *Krukoff 8254*, Sao Paulo de Olivenca, basin of Rio Solimoes (NY).

15. CHRYSOPHYLLUM GRANATENSE Spreng. Syst. **1**: 667. 1825.

Nycterisition argenteum H.B.K. Nov. Gen. & Sp. 3: 238. t. 244. 1818.

Twigs slender, puberulent; leaves elliptic or elliptic-obovate, about 4–5.5 cm. long and 2–3 cm. wide, rounded to acute, glabrous and shining above, thinly white-sericeous beneath, closely and conspicuously striate above, the veins averaging about 0.5 mm. apart, partly obscured by the pubescence beneath; petioles about 6–8 mm. long; flowers small, about 6–9 in the axils, the pedicels about 3 mm. long; sepals rounded, a little over 1 mm. long, sericeous; corolla glabrous, the lobes evidently longer than the tube, reflexed; filaments attached in the corolla-throat, exserted; anthers glabrous, acute, subcordate at the base; ovary hairy, 5-locular, tapering to the glabrous 1.5 mm. style; stigma-lobes obscure; fruit unknown.

TYPE: *Humboldt & Bonpland*, "prope Jaen de Bracamoras, alt. 620 hex. Regno Novo-Granatense," in the present province of Cajamarca, Peru, in August (NY—photo).

Distribution: Known only from the type collection, Cajamarca, Peru.

I have seen no specimens of this species, but from the type-photo and original description it would seem to be related to the more southern *C. marginatum*, from which it differs in its more closely and conspicuously striate leaves, that are white-sericeous beneath, and in its longer style.

16. **Chrysophyllum dusenii** Cronquist, sp. nov.

Tree, young twigs slender, rufous-sericeous; leaves elliptic, abruptly short-acuminate, about 2.5–7.5 cm. long and 1–2.5 cm. wide, glabrous above,

finely, closely, and inconspicuously strigose beneath, much as in *C. inornatum;* primary lateral veins weak, straight or nearly so, ending in a distinct submarginal vein, neither crowded nor very distant, the secondary lateral veins few, trending parallel to the primary ones, and mostly obscure; petioles about 4–5 mm. long; flowers 1–4 in the axils, the pedicels slender, finely and closely hairy, 5–11 mm. long; sepals deltoid-ovate, acute, 1.3–1.5 mm. long, rufous-sericeous; corolla about 3.5–5 mm. long, glabrous, the lobes a little shorter than the tube, but split down 0.4–0.8 mm. farther on the outside, as in *C. panamense;* filaments short, attached at the level of the sinuses; anthers glabrous, about 0.6–0.7 mm. long; ovary short-hairy all over, abruptly contracted to the distinct glabrous 0.5 mm. style, 5-locular, or 6-locular in occasional 6-merous flowers; fruit unknown.

Arbor, ramulis rufo-sericeis, foliis ellipticis abrupte brevi-acuminatis ca. 2.5–7.5 cm. longis 1–2.5 cm. latis, supra glabris, infra tenuiter strigulosis pilis pallidis, venis tenuibus directis, venulis paucis obscuris ad venas parallelibus, petiolis ca. 4–5 mm. longis; flores 1–4 axillares, pedicellis gracilibus 5–11 mm. longis, sepalis rufo-sericeis acutis 1.3–1.8 mm. longis, corolla glabra 3.5–5 mm. longa lobis infra et intus connatis parte libera quam tubo breviore, filamentis fauce affixis, ovario 5–6-loculare stylo glabro 0.5 mm. longo; fructus ignotus.

TYPE: *Dusén 14284,* "Morretes opp. Facenda Marumby, in silva primaeva," April 4, 1914, Paraná, Brazil (S).

Distribution: Rio de Janeiro and Paraná, Brazil.

BRAZIL: Rio de Janeiro: *Glaziou 19596* (K). Sao Paulo or Rio de Janeiro: *Weir 468* (K). Paraná: *Dusén s.n.,* Volta Grande, August 7, 1911 (S); *Dusén 615a,* Volta Grande, July 3, 1914 (S).

17. CHRYSOPHYLLUM MARGINATUM (H. & A.) Radlk. Act. Congr. Bot. Anvers **1885**: 170. 1887.

Large shrub or small tree about 2–10 m. tall; leaves relatively small, about 1.5–10 cm. long and 5–40 mm. wide, narrowly or broadly elliptic to lanceolate, oblanceolate, ovate, or obovate, rounded or even retuse to obtuse of acute at the apex, varying from essentially glabrous to strigose or puberulent along the midrib beneath, or loosely rufous-tomentose on the lower surface; primary lateral veins fairly numerous, parallel and nearly straight, usually impressed above, not much if at all raised beneath, the leaf appearing loosely and weakly striate; secondary lateral veins obscure or sometimes forming an evident reticulum, mostly parallel to the primary ones, and not always sharply distinguishable from them; petioles about 2–8 mm. long; flowers tiny, clustered in the axils or at recently defoliated nodes, subsessile or on pedicels up to 4 mm. long; sepals about 0.5–0.8 mm. long, rounded, rufous-strigose; corolla about 1.7–2.2 mm. long, the lobes 0.9–1.3 mm., often rufous-strigose on the outside; filaments attached at the corolla throat, where a slight thickened ring is more or less evident; anthers about 0.35–0.6 mm. long; ovary shortly rufous-hairy, its faintly lobed style 0.2–0.5 mm. long; fruit black, ellipsoid to subglobose, about 5–10 (rarely 13) mm. long; seed solitary, the scar basilateral, large, retuse, as broad as long, not reaching to the middle of the seed.

TYPE: *Tweedie 41, 52,* and *53,* from Uruguay, are cited in the original description. An unnumbered *Tweedie* collection is at K.

Local names: Picazó rembiú (Chaco).

Distribution: Uruguay, northern Argentina, and Bolivia to Matto Grosso and Minas Geraes, Brazil.

KEY TO THE VARIETIES OF CHRYSOPHYLLUM MARGINATUM

1. Leaves glabrous at maturity or merely strigose or puberulent along the mibrid beneath.
   2. Corolla more or less appressed-hairy, at least toward the base; pedicels evident, slender. A. var. *marginatum*.
   2. Corolla glabrous, rarely with a few inconspicuous appressed hairs; pedicels generaly very short and stout, the flowers thus closely aggregated. B. var. *obversum*.
1. Leaves more or less persistently tomentose with loose rufous hairs beneath. C. var. *tomentosum*.

17A. CHRYSOPHYLLUM MARGINATUM var. **marginatum** Cronquist, var. nov.

Myrsine marginata H. & A. Journ. Bot. 1: 283. 1834.

Chrysophyllum marginatum Radlk. Act. Congr. Bot. Anvers. 1885: 170, sensu stricto. 1887.

C. maytenoides Mart. Herb. Fl. Bras. 177. 1837.

C. myrtifolium Mart. Herb. Fl. Bras. 176. 1837.

C. maytenoides var. *myrtifolium* Miq. in Mart. Fl. Bras. 7: 100. 1863.

Myrsine grisebachii Hieron. Bol. Acad. Nac. Córdova 4: 365. 1881.

Chrysophyllum maytenoides α *normale* Kuntze, Rev. Gen. 3²: 194. 1898.

C. maytenoides β tenue Kuntze, loc. cit.

C. grisebachii Mez, Pflanzenr. 4: 397. 1902.

C. ilicioides Rusby, Bull. N. Y. Bot. Gard. 4: 466. 1907.

Flowers borne on evident slender pedicels; base of corolla-lobes and top of tube rufous-strigose, sometimes scantily so; leaves glabrous or merely slightly hairy along the midrib beneath, generally broadest at or below the middle.

Distribution: Range of the species.

BRAZIL: *Riedel 167* (US); *Sello 3528* (G, US); *Sello 4149* (C). Matta Grosso: *Hoehne 4260*, Cuyabá (F), *4692*, Cuyabá (F); *Kuntze s.n.*, July, 1892, Villa Maria (F); *Malme 1843*, Cuyabá (S), *1843a* (S); *Dorrien Smith 12*, Campo Grande, 150 miles southeast of Corumbá (K). Minas Geraes: *Mexia 5844*, Serra do Rio Grande (C, F, G, MO, NA, NY, PA, S, US). Rio de Janeiro: *Glaziou 8226* (K, P, S, US), *12069* (K), *14054* (K). Sao Paulo: *Brade 5755* (S); *Hoehne 39*, Butantan (F); *Mosén 1447* (S); *Usteri 15938*, Pinneiro (F). Santa Catharina: *Ule 1095* (US). Rio Grande do Sul: *Lindman A1429*, Val de Serra (S); *Lindman A1623*, Porto Alegro (S); *Malme 70* (S, US); *Malme 1461*, near Porto Alegro (S); *Malme 1612* (G, S); *Leite 2548*, São Leopoldo (G); *Sello 1170* (C, PA, S). PARAGUAY: *Balansa 2236* (F, S), *4490* (F); *Fiebrig 5405* (G, K, US), *5949* (US), *6126* (F, G, K, US); *Hassler 437* (K), *564* (K), *3010* (K), *11201* (A, F, K), *11734* (A, G, K, MO, US); *Jorgensen 3760* (A, F, G, MO, NY, PA, S, US); *Kuntze s.n.*, September 1892 (F, NY); *Malme 842* (G, S, US); *Morong 701* (G, Mich, MO, PA, US), *701A* (C, US), *841* (C, G, K, Mich, MO, NY, PA, US); *Rojas 1694* (S). BOLIVIA: La Paz: *Bang 2157*, Coripati, Yungas (NA, NY, PA, US); *Buchtien 4359*, Milluguaya, in Nord-Yungas (US). Santa Cruz: *Herzog 1352* (S); *Kuntze s.n.*, La Cruz (NY). URUGUAY: *Lorentz s.n.*, April, 1876 (G, US). ARGENTINA: Jujuy: *Venturi 5307*, Sierra do Calilegua (G, US). Tucuman: *Burkart 5368*, Sierra de Jan Javier (G); *Jorgensen 1918*, Alpachiri (G); *Lorentz 183*, La Cruz (K); *Lorentz & Hieronymus 1040* (F, US); *Parodi 11088* (F); *Venturi 233* (F, G); *Venturi 844*, Barranca Colorado (A, NY,

S, US); *Venturi 6039*, Cumbre de Taficillo (A, US); *Venturi 10349*, Cerro del Campo (MO, S). Chaco: *Jorgensen 2099*, Los Palmas (G, MO, US); *Schulz 886*, Colonia Benitez (NY); *Meyer 728*, Fontana (G). Misiones: *Curran 713*, Puerto Leon (NY); *Grüner 1029*, Loreto (NY); *Rodriguez 350*, Santa Ana (G, NY, US). Corrientes: *Bonpland s.n.* (F); *Parodi 11989*, San Luis del Palmar (G, NY).

17B. CHRYSOPHYLLUM MARGINATUM var. **obversum** (Miq.) Cronquist, comb. nov.

C. ebenaceum Mart. Herb. Fl. Bras. 176. 1837.
C. martianum A. DC. Prodr. **8**: 161. 1844.
C. ebenaceum var. *obversum* Miq. in Mart. Fl. Bras. **7**: 100. 1863.
C. ebenaceum var. *pedunculatum* Miq. in Mart. loc. cit.
C. ebenaceum var. *latifolium* Miq. in Mart. loc. cit.
C. ebenaceum var. *longifolium* Miq. in Mart. loc. cit.

Flowers mostly subsessile or on very short stout pedicels, thus more or less glomerate; corolla glabrous, or very nearly so; style very short, about 0.2–0.3 mm. long; leaves glabrous or merely slightly hairy along the midrib beneath, often broadest above the middle.

TYPE: *Martius 886*, Saõ Paulo, Brazil (G, MO, NY).

Distribution: Saõ Paulo, Minas Geraes, Matto Grosso, and Rio de Janeiro, Brazil.

BRAZIL: *Burchell 3915* (K), *4681–16* (G), *4705–10* (G), *6988–3* (G, K); *Martius 887* (F, K, NY, PA). Matto Grosso: *Malme 1394*, Cuyabá (G, S, US); *Riedel 847*, Cuyabá (US). Minas Geraes: *Barreto 7307*, Bello Horizonte (F); *Clausen 45* (F, P), *150* (F, NY); *Martius 272* (G—photo); *St. Hillaire 381* (P). Rio de Janeiro: *Glaziou 5930* (F, K, S), *8793* (A, K, NY, S). Saõ Paulo: *Brade 5755*, Moáca (F), *5766* (S); *Hoehne 28793* (cult.) (A, C, F, NY, S); *Loefgren 2940* (F); *Mosen 4659* (S).

17C. CHRYSOPHYLLUM MARGINATUM var. **tomentosum** (Miq.) Cronquist, comb. nov.

C. guilleminianum A. DC. Prodr. **8**: 161. 1844.
C. ebenaceum var. *tomentosum* Miq. in Mart. Fl. Bras. **7**: 100. 1863.

Leaves more or less persistently tomentose beneath with loose rufous hairs; otherwise much like var. *obversum*, but the leaves less often obverse.

TYPE: Specimens from Minas Geraes by *Widgren* (K, S), and *Pohl* are cited.

Distribution: Minas Geraes, Sao Paulo, and Rio de Janeiro, Brazil.

BRAZIL: *Burchell 4812* (K); *Riedel 8842* (or *28421*) (NY, US); *Pohl 1461* (F, G, US). Sao Paulo: *Guillemin 499* (F); *Mosén 1447*, Mozy guassu (S), *1449* (S); *Mosén 1448*, Mogy mirim (S), *4659* (S). Minas Geraes: *Brito 19888*, Belo Horizonte (F); *Mosén 1899*, Caldas (S), *1450* (G); *Regnell 855*, Caldas (G, K, S, US). Rio de Janeiro: *Glaziou 12936* (A, K, P).

The name *Chrysophyllum marginatum* (H. & A.) Radlk. is technically a hyponym, and may be considered to be validated here.

Several varieties have been based on differences in size and shape of the leaves, but these features are so variable as to be of very dubious taxonomic value. Except that var. *obversum* more commonly has the leaves broadest above the middle than do the other varieties, it is to be presumed, until careful field study proves the contrary, that variation in size and shape of the leaves of *C. marginatum* is of no taxonomic significance.

18. CHRYSOPHYLLUM OVALE Rusby Mem. N. Y. Bot. Gard. **7**: 320. 1927.

Tree; leaves glabrous, elliptic or elliptic-ovate, conspicuously acuminate, about 3–11 cm. long and 1.5–6 cm. wide; primary lateral veins straight or nearly so, neither crowded nor very distant; larger secondary veins mostly trending parallel to the primaries, and not always sharply separable from them; petioles about 4–12 mm. long; flowers clustered in the axils or at recently defoliated nodes, borne on slender pedicels about 4–6 mm. long, very similar to those of *C. marginatum*, but slightly larger, the corolla about 2.5 mm. long; fruit broadly ellipsoid or subglobose, about 1.5–2 cm. long; seed solitary, with a broad basilateral scar extending about two-thirds its length.

TYPE: *White 1384A*, Esperanza Falls, near the northern tip of Bolivia, 500 feet (NY, US).

Distribution: From Loreto, Peru, to northern Bolivia.

PERU: Loreto: *Klug 2324*, Florida, Río Putumayo, at mouth of Río Zubineta, 180 m. alt. (A, F, US). BRAZIL: *Ule 9694*, Monte Mo, Río Acre, either in Acre Territory or in adjacent Amazonas (K).

19. **Chrysophyllum lucentifolium** Cronquist, sp. nov.

Tree or arborescent shrub; leaves glabrous, shining, elliptic to elliptic-oblanceolate or elliptic-obovate, generally acute or acuminate at the apex, tapering to the base, about 4–10 cm. long and 2–4.5 cm. wide; primary lateral veins prominent, well-spaced, generally arcuate toward the margins; secondary lateral veins conspicuous, irregular, loosely reticulate; petioles about 5–10 mm. long; flowers subsessile, borne single or few together in the axils or at recently defoliated nodes; sepals about 1.2–2.0 mm. long, sparsely strigose, the inner fringed-ciliolate; corolla glabrous, about 2.7–3.0 mm. long, the lobes equaling or much exceeding the tube; filaments attached at or slightly below the level of the sinuses, but their traces raised and conspicuous to the base; anthers 0.9–1.1 mm. long; ovary hairy, 5-lobed, 5-locular; style short and stout, about 0.5 mm. long; stigma-lobes 5; fruit about 1.5–2 cm. long, ovoid or subglobose, somewhat sulcate, at least when dry, between the several seeds; seeds nearly as long as the fruit, each with a linear scar extending its full length.

Arbor vel frutex arborescens, foliis glabris lucidis ellipticis vel elliptico-oblanceolatis vel elliptico-obovatis, apice acuminatis basi cuneatis 4–10 cm. longis 2–4.5 cm. latis, venis prominentibus arcuatis, venulis prominentibus irregulariter reticulatis, petiolis 5–10 mm. longis; flores pauci axillares subsessiles, sepalis 1.2–2.0 mm. longis sparse strigosis, corolla glabra 2.7–3.0 mm. longa, lobis tubum aequantibus vel excedentibus, filamentis fauce affixis, ovario 5-loculare; fructus ovoideus vel subglobosus sulcatus 1.5–2 cm. longus, seminibus paucis cicatrice lineari.

TYPE: *Riedel s.n.*, Macahé, Rio de Janeiro, June 1832 (US).

Distribution: Rio de Janeiro, Brazil.

BRAZIL: Rio de Janeiro: *Riedel 1129*, October, 1832 (NY, US).

This species is probably related to *C. gonocarpum*, from which it differs in its shining, mostly smaller leaves, which are glabrous from the first, shorter corolla and style, and in having the filaments attached near the level of the sinuses, instead of toward the base of the tube.

20. CHRYSOPHYLLUM CAINITO L. Sp. Pl. 192. 1753.

Tree sometimes as much as 30 m. tall; leaves elliptic or oblong, generally abruptly short-acuminate at the apex, up to about 16 cm. long and 8 cm. wide, soon glabrous and shining above, persistently rufous-sericeous or -tomentulose beneath, sometimes becoming a little paler in age; primary lateral veins straight or slightly curved, neither crowded nor very distant, not sharply separable from the larger secondary ones, which trend parallel to them; flowers numerous in axillary clusters, the pedicels closely rufous-hairy, about 5–15 mm. long; sepals about 1.0–1.2 mm. long, closely rufescent, suborbicular; corolla about 3–5 mm. long, the tube glabrous, the lobes rufous-hairy except near the margins, somewhat ovate, more tapering than in most species, equaling or usually a little exceeding the tube; filaments attached a little above the level of the sinuses; anthers about 0.7–0.9 mm. long; ovary 7–12-locular, with a short style and discoid stigma, the stigma-lobes as many as the locules; fruit yellow, green, or purple, large, 3 cm. or more thick, sometimes as much as 12 cm. thick, mostly obovoid or subglobose, several-seeded; seeds flattened, obliquely obovate, with a broad lateral scar extending nearly their whole length.

TYPE: Linnaeus cites no specimens, but refers to several other publications.

Local names: Star-apple; caimito.

Distribution: Colombia to Surinam, north throughout the West Indies, and through Central America to southern Mexico. Widely cultivated and naturalized, so that the original range is uncertain; almost certainly native in the West Indies, and probably also in northern South America, but probably only naturalized on the North American continent.

COLOMBIA: *Mutis 84* (US), *1038* (US). Atlantico: *Elias 992*, Barranquilla (F, US). Bolivar: *Curran 234*, Mompos Island (G, US); *Killip & Smith 14486*, Turbaco (A, G, NY, US). Norte de Santander: *Cuatrecasas, Schultes & Smith 12229*, Sarare region (US). Antioquia: *Daniel 2282*, San Gerónimo (US). Vallé del Cauca: *Triana 2599*, El Espinal, valley of the Magdalena (K, NY, US). Tolima: *Barriga 8408*, Guyabal. VENEZUELA: Merida: *Fendler 2353*, near Tovar (G, K). Aragua: *Chardon 166*, El Rorozal (US). Bolivar: *Rusby & Squires s.n.* (NY). TRINIDAD: *Broadway s.n.*, September 16, 1918 (G, NY, US); *Eggers 45* (US). BRITISH GUIANA: *De La Cruz 2018*, Bartica, Essequibo River (G, MO, NY, US); *Gleason 921*, Rockstone (G, NY, US). SURINAM: *Lanjouw 109*, Charlesburg, near Paramaribo (S); *Pulle 6*, near Paramaribo (US).

21. CHRYSOPHYLLUM COCHLEARIUM LeComte, Notulae Syst. **4**: 63. 1923.

Tree; twigs slender, rufous-tomentose when young; leaves obovate or elliptic-obovate, about 4.5–7.5 cm. long and 2–4 cm. wide, closely sericeous with fine rich red hairs on both sides when young, soon glabrate above, and probably eventually so beneath; primary lateral veins about 8–12 pair, arcuate; secondary lateral veins obscure, loosely reticulate, the stronger ones mostly trending nearly at right angles to the primary veins; petioles about 1 cm. long; flowers in small clusters at defoliated nodes, the pedicels rufous-sericeous, about 1–2 mm. long; sepals hairy like the pedicels, about 1.5 mm. long; corolla about 3.0–3.5 mm. long, the lobes rufous-sericeous on the back, twice as long as the tube, or longer; filaments attached at the level of the sinuses, or a little above, slender, about 1 mm. long; ovary closely rufous-hairy, 5–6-locular; style glabrous, about 0.7–1.1 mm. long; stigma-lobes obscure; fruit unknown.

TYPE: *Benoist 224,* French Guiana (F—fragment).
Local name: Bois cuiller.
Distribution: Known only from the type collection, French Guiana.

22. CHRYSOPHYLLUM RUFUM Mart. Herb. Fl. Bras. 174. 1837.

C. rufum var. *acutifolium* Mart. Herb. Fl. Bras. 289. 1837.
C. tomentosum Freire-Allem. Trab. Comm. Sci. Expl. Bot. Rio de Janeiro 1: 69. 1866.

Small, much-branched tree about 5–15 m. tall; leaves elliptic or elliptic-lanceolate, usually acuminate, about 3.5–8 cm. long and 1.5–2.5 cm. wide, glabrous and shining above, sericeous-tomentose beneath with dull rufous hairs; primary lateral veins about 6–15 pair, fewer, more widely spaced, straighter, and more conspicuously bifurcate near the margins than in *C. pavonii;* secondary lateral veins trending parallel to the primary ones, the larger ones not always separable from them; petioles about 5–9 mm. long; flowers 6–7-merous throughout, clustered in the axils and at defoliated nodes as well, the pedicels slender, rufous-sericeous, about 3 mm. long; sepals hairy like the pedicels, about 1 mm. long; corolla sparsely rufous-hairy or glabrous, about 2.4–2.6 mm. long, the lobes twice as long as the tube, each bearing three thickened nerves within; filaments attached at the level of the sinuses, slender, flexuous or variously bent, the traces visible to the base; anthers cuspidate, about 0.8 mm. long, dehiscent to the base, but the walls remaining closely approximate along the line of dehiscence, except at the top, where they spread to form an evident apical pore; ovary short-hairy, 6–7-locular; style slender, about 0.8 mm. long; stigma-lobes obscure; fruit smooth, about 8–12 mm. long, or perhaps sometimes larger, 1–2-seeded, subpyriform; seeds obovoid, obtuse at the apex, acute at the base, the seed-coat regularly tuberculate, sulcate between the tubercles; seed-scar basilateral, suborbicular, extending about to the middle of the seed.

TYPE: *Martius 272,* in sylvis, Caa-tinga, Bahia, Brazil (G—photo).
Distribution: Bahia, Cara, and Rio de Janeiro, Brazil.

BRAZIL: Ceara: *Ule 9079,* Serra de Baturite (C, F, K). Bahia: *Martius 521,* Cruz de Casma (F, G, K, MO, NY); *Tuschnath 25* (F). Rio de Janeiro: *Glaziou 11146* (K).

The description of the fruit and seed for this species is taken from that given by Miquel in the Flora Brasiliensis.

23. **Chrysophyllum pavonii** Cronquist, nom. nov.

Nycterisition ferrugineum R. & P. Fl. Per. 2: 47. *pl. 187.* 1794.
Chrysiphyllum ferrugineum Steud. Nom. ed. 2. 1: 359. 1840, not Gaertn. f. 1805.

Tree with hard fulvous wood; latex turning blood-red when exposed to air; leaves somewhat astringent, elliptic-oblong, rounded to more commonly acute or acuminate, about 4–13 cm. long and 2–5 cm. wide, glabrous above, sericeous-tomentose beneath with lustrous deep-rufous hairs; primary lateral veins straight or slightly curved, bifurcate near the margins, about 12–25 pair, not always sharply separable from the larger secondary ones, which trend parallel to them; petioles about 1 cm. long; flowers clustered in the axils or at recently defoliated nodes, the pedicels rufous-sericeous, about 2 mm. long; sepals rufous-hairy like the pedicels, rounded, 1.1–1.3 mm. long; corolla about 3.0–3.5 mm. long, the lobes scarcely equaling the tube, the lobes and the upper part of the tube sericeous-strigose with rufous hairs;

filaments attached at the level of the sinuses, short and stout; anthers about 0.5–0.6 mm. long; stigma-lobes obscure; fruit unknown.

TYPE: One of two or more collections from Peru by *Ruiz & Pavon.* Specimens from apparently two different collections of this group are at F; two photographs are at G, and one at NY.

Local name: Chichimicuna.

Distribution: Known only from the original collections, Peru.

24. CHRYSOPHYLLUM JANUARIENSE Eichl. Vidensk. Meddel. **1870**: 206. 1871.

Twigs densely villous-tomentose with spreading rufous hairs; leaves elliptic-oblong, rounded to subcordate at the base, acute at the apex, about 7–13 cm. long and 3–6 cm. wide, soon glabrate and shining above, persistently hairy beneath with long-stalked two-forked rufous hairs, more densely so along the midrib; primary lateral veins about 9–14 pair, irregularly spaced, straight, bifurcate near the margins; secondary lateral veins loosely and irregularly reticulate, some of the larger ones sometimes parallel to the primary ones; petioles about 4–5 mm. long; flowers clustered in the axils, the pedicels densely spreading-hairy like the twigs and petioles; sepals short, broad, and rounded, hairy like the petioles; corolla glabrous, the lobes about equaling the tube; filaments inserted near the middle of the tube, slender, half as long as the cordate laterally villous anthers; ovary depressed-globose, densely rufous-hairy, 5-locular; style short, glabrous; stigma-lobes obscure; fruit unknown.

TYPE: Two collections by *Glaziou* from Rio de Janeiro were cited by Eichler. The first number, *1055,* is of plants past anthesis, without corollas (G, K, NY, P). Duplicates of the second number, *2598,* have flowers in maturing bud, the corollas ready to open (A, K). This number is accordingly selected as the type.

Distribution: Rio de Janeiro and perhaps elsewhere in Brazil.

BRAZIL: *Pearce s.n.*, Santa Ana, 3–4,000 feet, 1866 (K).

The Paris specimen cited above has the number 1055 marked out, and replaced with *8231.* There is also a collection at Kew bearing the numbers *8231 = 1005.*

25. CHRYSOPHYLLUM SPARSIFLORUM Klotzsch ex Miq. in Mart. Fl. Bras. **7**: 90. 1863.

C. sparsiflorum var. *fagifolium* Miq. in Mart. loc. cit.

Young twigs rufous-sericeous; leaves lance-elliptic to elliptic or elliptic-ovate, about 5–12 cm. long and 2–4.5 cm. wide, yellowish-sericeous on both sides when young, soon glabrate above, more tardily so beneath, the hairs loosely appressed, about 0.3–0.6 mm. long; primary lateral veins arcuate or unequally bifurcate near the margin, irregularly set, the secondaries mostly trending about parallel to them and not always sharply separable; petioles about 3–6 mm. long; pedicels about 1–4 in the axils, sericeous, 2–3 mm. long, deflexed or recurved at least before anthesis; sepals hairy like the pedicels, about 1.6–1.8 mm. long; corolla glabrous, about 3.5 mm. long, the lobes a little longer than the tube; filaments slender, shorter than the anthers, nearly or quite free from the tube; anthers cordate-ovate, minutely apiculate, about

1.5 mm. long, densely woolly-villous on the margins; ovary hairy, 5-locular, the style short, glabrous; stigma-lobes obscure; immature fruit glabrous, obovoid or subglobose, over 1 cm. long, single-seeded.

TYPE: *Schomburgk 680*, British Guiana (F—fragment, K).

Distribution: British Guiana, and Para, Brazil; certainly to be expected in northern Amazonas, Brazil.

BRITISH GUIANA: *Schomburgk 420*, Pirara (F). The Kew specimen cited above bears both numbers, *680* and *420*.

The description of the fruit is taken from Miquel's description, which is based on a specimen collected by Spruce near Santarem, Para, the type of var. *fagifolium*. A photograph of a plant in the Munich herbarium, labeled *Chrysophyllum sparsiflorum* var. *fagifolium*, agrees with this description, and may represent an isotype of the variety.

26. CHRYSOPHYLLUM PULCHERRIMUM Mart. & Eichl. ex Miq. in Mart. Fl. Bras. **7**: 92. 1863.

Tree up to 10 m. tall; young twigs rufous-sericeous; leaves elliptic or elliptic-ovate, rounded to acutish at the apex, about 4–11 cm. long and 2.5–5.5 cm. wide, glabrous above, persistently sericeous beneath with rich purplish-red hairs; venation of the usual chrysophylloid type, with straight bifurcate irregularly set primary lateral veins, and relatively few secondaries, these mostly parallel to the primaries; petioles about 1 cm. long; flowers several in axillary clusters, the pedicels slender and lax, rufous-sericeous, about 15–25 mm. long; sepals rufous-sericeous, about 2.5–3 mm. long; corolla a little longer than the calyx, nearly glabrous, the lobes shorter than or about equaling the tube; filaments slender, inserted about at the middle of the tube; anthers cordate-ovate, emarginate at both ends, long-villous; ovary rufous-sericeous, tapering to the glabrous 1 mm. style; fruit unknown.

TYPE: *Sello 1036*, eastern Brazil (C, F—photo and fragment, G—photo, K, NY—photo). Another collection from eastern Brazil, by Freireiss, is also cited in the original description.

Distribution: Known only from the original collections, in eastern Brazil. A specimen at K, without designation of the collector, bears the data, "Camamée, Prov. do Bahia." It is very probably an isotype.

27. CHRYSOPHYLLUM SPLENDENS Spreng. Syst. Veg. **1**: 666. 1825.

C. amplifolium A. DC. Prodr. **8**: 159. 1844.

Tree about 10 m. tall; young twigs closely rufous-sericeous; leaves elliptic-oblong to broadly elliptic-oblanceolate, about 10–30 cm. long and 4–12 cm. wide, rounded to abruptly short-acuminate or merely acutish at the apex, glabrous above, densely and persistently sericeous beneath with coppery-rufous hairs; primary lateral veins about 10–22 pair, rather irregularly set, mostly arcuate near the margins; secondary lateral veins few, the larger ones mostly trending parallel to the primaries; petioles about 8–17 mm. long; flowers clustered in the axils, the pedicels rufous-sericeous, about 7–13 mm. long; sepals hairy like the pedicels, about 2.0–2.8 mm. long; corolla about 3.5 mm. long, moderately rufous-strigose or rufous-sericeous below, the hairs concentrated near the sinuses; corolla-lobes from a little shorter

to a little longer than the tube; filaments short, attached about at the middle of the tube; anthers about 0.9–1.1 mm. long, villous, sometimes sparsely and shortly so; ovary sulcate, closely hairy, 5-locular, tapering to the 1.5 mm. style, which is glabrous above; stigma-lobes 5; fruit unknown.

TYPE: None given; possibly one of the *Sello* collections cited below.

Distribution: Bahia and perhaps elsewhere in eastern Brazil.

BRAZIL: *Sello 375* (G—photo), *798* (K). Bahia: *Riedel 8*, near Ilheos (NY, US); *Froes 1077*, road to Pontal, basin of Rio Santa Ana (A); *Blanchet 3202A* (G—photo, NY—photo).

28. CHRYSOPHYLLUM ARENARIUM Freire-Allem. Trab. Comm. Sci. Expl. Bot. Rio de Janeiro **1**: 72. *pl. 22.* 1866.

Much-branched shrub or small tree sometimes 7 m. tall; twigs roughened by the numerous lenticels, loosely rufous-sericeous when young, soon glabrate; leaves ovate or elliptic, acutish or bluntly acuminate, about 1.5–6 cm. long and 1–4 cm. wide, sericeous-tomentose with more or less rufous hairs when unfolding, very soon glabrate on both sides, or sometimes with some persistent hairs along the midrib beneath; primary lateral veins straight, impressed above, not much raised beneath, about 1.5–4 mm. apart; secondary lateral veins obscure; petioles about 3–4 mm. long; sepals more or less rufous-strigose, about 0.8–0.9 mm. long; corolla glabrous, about 2.0 mm. long, the lobes equaling or much exceeding the tube; filaments short, attached near the middle of the tube; anthers long-villous on the margins, cordate-ovate, retuse or obscurely apiculate at the summit, about 1.0 mm. long; ovary short-hairy, 5-locular; style glabrous, scarcely 0.5 mm. long; stigma-lobes obscure; fruit obovoid, about 12–13 mm. long and 8–9 mm. thick, subtruncate at the apex, with thin pulp; seed solitary, obovoid, with broad basilateral scar extending about two-thirds of the way to the summit.

TYPE: *Freire-Allemao s.n.*, "Habitat in arenosis circa civitatem Fortaleza dictam, in provincia Ceara, April."

Distribution: Ceara to Rio de Janeiro, Brazil.

BRAZIL: Ceara: *Luetzelburg 26445*, Araras Carasco, Serra do Araripe (F). Rio de Janeiro: *Glaziou 11147* (K), *11148* (K).

29. CHRYSOPHYLLUM INORNATUM Mart. Herb. Fl. Bras. 176. 1837.

C. lanceolatum Casar. Stirp. Bras. Dec. **7**: 64. 1843; acc. to Miq.

Twigs slender, yellowish-sericeous when young; leaves lance-elliptic, acuminate, about 4–10 cm. long and 12–28 mm. wide, glabrous above, finely strigose or sericeous-strigose beneath with closely appressed whitish hairs about 0.1–0.3 mm. long, sooner or later glabrate; primary lateral veins mostly straight or nearly so and bifurcate near the margins, not sharply separable from the secondary ones, which trend parallel to them, the lateral veins thus appearing rather crowded, about 1–3 mm. apart; petioles about 2–7 mm. long; flowers solitary or few in the axils, the pedicels slender, sericeous, about 5–8 mm. long; sepals about 2 mm. long or less, ovate, subacute; corolla about 3.0 mm. long, glabrous, the lobes about equaling the tube; filaments short, attached near the base of the tube; anthers apiculate, cordate at the base, villous; ovary hairy, 5-locular; style short, glabrous; stigma obscurely 5-lobed; fruit unknown.

Type: *Sello 4530*, toward Austrum, Rio Grande do Sul (C, F—photo and fragment, G—photo, K, NY—photo, US).

Distribution: Rio Grande do Sul to Rio de Janeiro, Brazil.

30. Chrysophyllum flexuosum Mart. Herb. Fl. Bras. 98. 1837.

C. elegans Raunk. Vidensk. Meddel. **1889**: 9. 1889.

Small tree up to about 12 m. high; leaves elliptic or elliptic-oblong, mostly acute or more commonly acuminate, about 6–40 cm. long and 2–12 cm. wide, glabrous above, sericeous-strigose with whitish hairs beenath, the hairs about 0.3–0.6 mm. long, sooner or later glabrate; primary lateral veins well-spaced, about 5–15 mm. apart, mostly arcuate near the margins; secondary veins not very prominent, generally forming a loose open reticulum; petioles about 8–20 mm. long; flowers borne in the axils or at recently defoliated nodes, about 2–13 in a cluster, the pedicels about 6–16 mm. long; sepals about 1.5–3.5 mm. long, appressed-hairy; corolla about 3.7–7.0 mm. long, glabrous or nearly so, the lobes a little shorter than the tube; filaments attached at or a little below the middle of the corolla-tube, longer than the anthers; anthers villous, pointed, about 1.0–1.4 mm. long; ovary appressed-hairy, narrow, tapering gradually to the stout glabrous style about 1.2–2.5 mm. long; fruit unknown.

Type: *Martius 102*, in acumine montis Corcovado, Brazil, 1838 (F, G, K, MO, NY, PA, US).

Distribution: Minas Geraes, Rio de Janeiro, and Sao Paulo, Brazil.

Brazil: *Burchell 1800* (G, K); *Glaziou 793* (US); *Pohl 997* (K); *Riedel 15* (US), *1290* (US); *Sello 1682–836* (C). Minas Geraes: *Mexia 5427*, Viçosa (C, F, G, MO, NY, PA, S, US). Rio de Janeiro: *Brade 42* (G); *Glaziou 193* (K), *1355* (NY), *9501* (K), *11582* (A, C—photo, K, P, S), *17124* (A, K, NY); *Guillemin 250*, Mont du Corcovado (F, P); *Hoehne 24880*, Tijuca (F); *Riedel 563*, Macahé (NY, US); *Riedel 1223* (NY, US); *Riedel 3012*, Corcovado (US). Sao Paulo: *Mosén 2896*, Santos (K, S); *Mosén 3428*, Santos (S).

DOUBTFUL AND EXCLUDED SPECIES

Chrysophyllum alnifolium Engl. Bot. Jahrb. **12**: 522. 1890. = *Pouteria engleri* Eyma.

C. ambelaniifolium Sandw. Kew Bull. **1931**: 476 = **Oxythece ambelaniifolia** (Sandw.) Cronquist, comb. nov.

C. aquaticum H.B.K. Nov. Gen. & Sp. **3**: 236. 1818. Nom. dub. based on sterile specimens.

C. brasiliense A. DC. Prodr. **8**: 156. 1844. = *Sarcaulus brasiliensis* (A. DC.) Eyma.

C. bumelioides Mart. Herb. Fl. Bras. 177. 1837. = *Pradosia lactescens* (Vell.) Kuhlm.

C. buranhem attr. to Riedel by Hook. & Jacks. Kew Ind., as a synonym. Buranhem was merely listed by Riedel as the vernacular name of an unidentified species of "*Chrysophyllum.*" The plant is a *Pradosia*.

C. cayennense A. DC. Prodr. **8**: 160. 1844. = *Pouteria cayennensis* (A. DC.) Eyma.

C. crotonoides Klotzsch ex Hook. & Jackson, Ind. Kew. Suppl. **1**. = *Pouteria crotonoides* (Pierre) Baehni.

C. eximium Ducke, Bull. Mus. Hist. Nat. Paris II. **4**: 744. 1932. = **Ecclinusa eximia** (Ducke) Cronquist, comb. nov.

C. cuspidatum Hoehne, Ostenia 302. 1933. An undescribed new genus.

C. gardneri Mart. & Miq. in Mart. Fl. Bras. **7**: 102. 1863. = *Pouteria gardneri* (Mart. & Miq.) Baehni.

C. glaucescens Engl. Bot. Jahrb. **12**: 521. 1890. = **Oxythece glaucescens** (Engl.) Cronquist, comb. nov.

C. glycyphloeum Casar. Stirp. Bras. Dec. **1**: 12. 1842. = *Pradosia glycyphloea* (Casar.) Kuhlm.

C. humboldtianum Roem. & Schult. Syst. **4**: 813. 1819. Nom. dub.

C. inophyllum Mart. ex Miq. in Mart. Fl. Bras. **7**: 105. 1863. = *Pradosia inophylla* (Mart.) Ducke.

C. klugii Baehni, Candollea **7**: 134. 1936. = **Ecclinusa klugii** (Baehni) Cronquist, comb. nov.

C. leptocarpum Spruce ex Baehni, Candollea **9**: 427. 1942. = *Oxythece leptocarpa* Miq. in Mart. Fl. Bras. **7**: 106. 1863.

C. longifolium Mart. & Eichl. ex Miq. in Mart. Fl. Bras. **7**: 97. 1863. Insufficiently known; certainly none of the otherwise known species of *Chrysophyllum*. Perhaps a *Pouteria*.

C. macoucou Aubl. Pl. Gui. **1**: 233. *pl. 92*. 1775. Nomen confusum, based on fruit of *Chrysophyllum cainito* and foliage of some other plant.

C. macrophyllum Lam. Tab. Encyc. **2**: 44. 1793. = *Pouteria macrophylla* (Lam.) Eyma.

C. macrophyllum Mart. Herb. Fl. Bras. 175. 1837. = *Sarcaulus brasiliensis* (A. DC.) Eyma.

C. manglillo Lam. Tab. Encyc. Tab. Encyc. **2**: 45. 1793. = *Myrsine manglilla* (Lam.) R. Br.

C. melinoni Engl. Bot. Jahrb. **12**: 521. 1890. = *Micropholis guyanensis* (A. DC.) Pierre.

C. michino H.B.K. Nov. Gen. & Sp. **3**: 236. 1818. Nom. dub.; perhaps a species of *Manilkara*.

C. minutiflorum Britt. Bull. Torrey Club **48**: 337. 1922. = *Pouteria minutiflora* (Britt.) Sandw.

C. oleaefolium Spruce ex Miq. in Mart. Fl. Bras. **7**: 101. 1863. = *Oxythece* sp.

C. oppositum Ducke, Trop. Woods **71**: 18. 1942. = **Ecclinusa opposita** (Ducke) Cronquist, comb. nov.

C. parviflorum Casar. Stirp. Bras. Dec. **7**: 63. 1843. Nom. dub.; possibly not sapotaceous.

C. pumilum Chod. & Hass. Bull. Herb. Boiss. II. **7**: 674. 1907. = **Ecclinusa pumila** (Chod. & Hass.) Cronquist, comb. nov.

C. pumilum f. *glabrescens* Chod. & Hass. loc. cit. = praec.

C. pyriforme Willd. Sp. Pl. **1**: 1084. 1797. A substitute name for *C. macoucou*, q.v., supra.

C. ramiflorum (Mart.) A. DC. Prodr. **8**: 158. 1844. = *Ecclinusa ramiflora* Mart.

C. reticulatum Engl. Bot. Jahrb. **12**: 522. 1890. = *Pouteria reticulata* (Engl.) Eyma.

C. rufocupreum Ducke, Arch. Inst. Biol. Veg. Rio de Janeiro **2**: 67. 1935. = **Ecclinusa rufocuprea** (Ducke) Cronquist, comb. nov.

C. sessiliflorum Poir. Encyc. Suppl. **2**: 16. 1811. Nom. dub.

C. schomburgkianum A. DC. Prodr. **8**: 157. 1844. = **Pradosia schomburgkiana** (A. DC.) Cronquist, comb. nov.

C. ulei Krause, Notizbl. Bot. Gart. Berl. **6**: 171. 1914. = **Ecclinusa ulei** (Krause) Gilly in herb.

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THE CASE OF THE VANISHING FICUS RACEMOSA

MARY F. BARRETT

Is it possible that *Ficus racemosa*, a well-described and clearly illustrated species, disappeared after it had been reported more than 30 times and had been said to be cultivated in several botanical gardens? Why, 125 years after its ancestral history began, did reports of it become progressively less definite? Why was the authorship of the name *racemosa* often ascribed to other writers and texts than to Linnaeus, Sp. Pl. ed. 1? What, if any, is the relationship between *F. racemosa L.* and *F. glomerata* Roxb.? What is the synonymy of the species?

HISTORY AND CHARACTERS OF FICUS RACEMOSA

The development of knowledge of characters of *F. racemosa* reverses the usual process, since the first description of the tree is the best. Later characterizations added few valuable facts and some incorrect statements. This deterioration of information must be recorded here, since it played a part in the disappearance of *F. racemosa*.

Almost all writers on this species agree with Linnaeus' choice of *Atty-alu* Rheede as the prototype of *F. racemosa*. This tree was described in detail and well illustrated by Rheede (1678) under the name of *Atty-alu* in the text, *Atti-alu* on the plate. The text says that it grows in sandy places (in Malabar, India) and is a tall tree with a very thick trunk, thick roots spreading above and beneath the ground, long branches with dense foliage, and a very milky latex which reddens on exposure to the air. No mention is made of aërial roots, although the ground roots are said to have fibrous lateral rootlets. The petioles are stout. The blades are described as "oblong-round," twice as long as wide, gradually narrowed to an apical cusp, rounded at the petiole, soft, bare, smooth, shining green on the upper surface and bright beneath, with veins arched near the margin and reflexed, and with many transverse veins. Figure 1 B shows a typical leaf of "*Atti-alu*" in which some significant characters not included in the text are the long basal veins, the rather few secondary lateral veins, the lack of an inframarginal vein, and the indistinct, barely suggested veinlets.

The figs of *Atty-alu* are "like our figs" (*F. carica*) in part. Many receptacles are clustered in the same mass, according to the text. The plate shows them in a leafless simple raceme growing from a lower branch which bears one leaf near the trunk. Some figs are almost globose and others turbinate. The broad apex is a little depressed around the closed mouth, and the base

is slightly narrowed to a peduncle about 1 cm. long and 2–3 mm. thick. The height and greatest width of the receptacles measure about 3 cm. The surface is said to be more or less hairy, and to turn from green to red. No basal bracts are pictured. Fruits inside the receptacle are mentioned as "grains," and

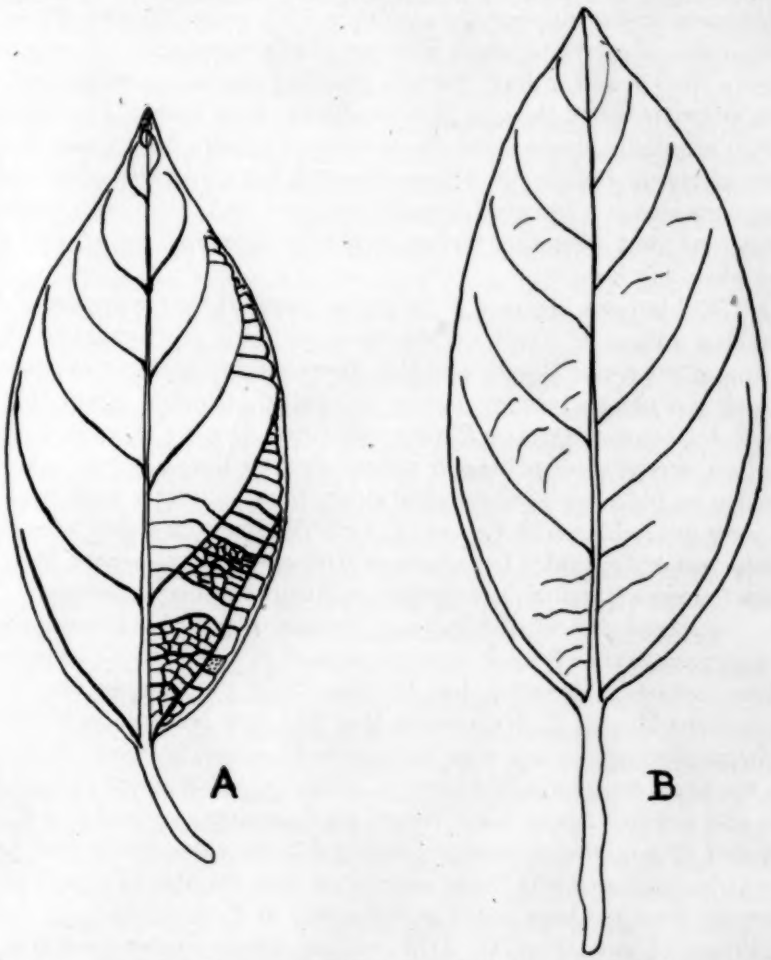

FIG. 1. A, under surface of a leaf from a living tree labeled *Ficus glomerata;* Miami, Florida. The left half shows the appearance of the veins in a fresh leaf; the right half indicates the veining apparent in a dry specimen. B, copy of a leaf of *Atty-alu* (*Atti-alu*) Rheede, Hort. Mal. 1: *pl. 25.* × 0.75.

illustrated, too indefinitely, in a longitudinal drawing of the inside of the fig. No data on flowers are given. It is stated that the tree bears edible fruit two or three times a year, and that its roots and figs have medicinal value.

At the end of Rheede's text Syen, an editor, added a Latin name: *Ficus*

malabarensis folio oblongo, acuminato, fructu vulgari aemulo. Syen's polynomial was used by Ray (1688), with due credit to its author, as the title of the species; but later references to this name were connected with Ray rather than Syen.

Linnaeus first mentioned the species in 1749 under the title *Ficus foliis ovatis acutis integerrimis, caule arboreo, fructu racemoso;* and referred to *Atty-alu* Rheede and to Ray. Thus he modified and added to the leaf characters and emphasized the type of fruit cluster. Here it should be noted that *racemus* originally meant simply a cluster and usually was exemplified by a cluster of grapes. Rheede did not use the word, but illustrated what is almost the modern idea of a raceme. Linnaeus may have had the present conception of that term; but some later writers evidently visualized bunches of receptacles when they used it.

In 1753 Linnaeus included *F. racemosa* among the seven species of *Ficus* in the first edition of *Species plantarum*, using his polynomial of 1749 as description and citing Rheede and Ray. Here and in the next two editions of the book the name given by Rheede is spelled *Alty-alu*. From this time through 1820 most writers on *F. racemosa* listed *Atty-alu* as a synonym, and almost all, except those editing or commenting on Rheede's text, misspelled the name as Linnaeus's printer had done, thus indirectly confessing that they were unfamiliar with its source. In 1822 Hamilton called attention to the incorrect orthography, but allocated *Atty-alu* to *F. glomerata*. Most later writers followed Hamilton's correction, although not his synonymy.

In the second and third editions of *Species plantarum* Linnaeus added *Grossularia domestica* Rumph. as a synonym of *F. racemosa*. This species has not been definitely identified, but Merrill (1917) has thought that it is *F. trematocarpa* Miq. or *F. descaineana* Miq. The very poor plates illustrating it show an excavated trunk such as is made by epiphytic roots, aërial roots from the branches, leaves like those of *Atty-alu*, but without distinct basal veins, and axillary figs on leafy twigs: all characters not found in *F. racemosa*. But *Grossularia domestica* continued to be cited under that species and may be the reason why the second rather than the first edition of *Species plantarum* often has been stated as the source of *F. racemosa*.

Editions 12 and 13 (1767, 1770) of Linnaeus's *Systema naturae* contained the additional and significant statement that the tree had impressed-punctate leaves sprinkled with white points. The characterization in these books was used also in editions 13, 14, and 15 (1774, 1784, and 1797, 1798) of *Systema vegetabilium* and was quoted by several later writers. However, Gmelin's revised 13th edition (1791) of *Systema naturae*, and Turton's English edition (1806) of Gmelin's work described the tree as having erect branches, elliptical-oblong leaves which were glabrous, and pale on the under surface, and pedunculate receptacles: characters evidently drawn from Thunberg (1786, see below).

Up to 1806 very few reports since Rheede's showed evidence of actual observation of *F. racemosa*, or indicated locations other than India or the East Indies. But Philip Miller, who later was said to have cultivated it in England in 1759, spoke of it in his *Gardener's dictionary* of that date under the polynomial given by Linnaeus in 1749, saying that it was a tree 25 ft. high, with many branches, oval-pointed, "lucid" green, smooth leaves, and small inedible "fruits" in clusters from the sides of the branches. In the 1768 edition of his work he inserted the word *Racemosa* after *Ficus* in the title. Aiton (1789) included *F. racemosa* in his book on Kew Gardens and referred to Miller (1759). Aiton drew his description of this actual plant from Linnaeus (1784), and called it the Red-wooded Fig Tree. Martyn's edition (1807) of Miller's text shows less evidence of first-hand acquaintance, for he quotes Thunberg (1786) almost word for word, with the addition of "points" from Linnaeus (1784). The second edition of Aiton's work (1813) changed the previous description of *F. racemosa* to one made by Willdenow (1806), and called the tree the Cluster Fig. Thunberg (1786) compiled, at some length, descriptions apparently taken from eye-witnesses. He added to the characters listed above under Gmelin the statements that the branches were ferruginous, the twigs scattered and short, the leaves 2.5–7.5 cm. or more in length, on petioles 2.5 and 5 cm. long, and the figs the size of a plum. Neither he nor Miller mentioned "points."

Lamarck (1788) made a detailed, but confusing summary of the species, first quoting the Linnean description in the *Systema* and his references, including "*Atty-alu*," and then characterizing var. β as having narrow lanceolate leaves. He cited two references for the variety, which he said was the *Atti* of the Indians. Neither reference belongs to this plant, if it is related to *F. racemosa*. Finally Lamarck described what apparently was intended for the type, but, as Hamilton (1822) pointed out, resembled *Grossularia domestica*. Although he added that young trees grew in the (French) Royal Gardens his identification seems doubtful.

Vahl (1806) described *F. racemosa* as having hairy twigs and petioles, small substriately veined leaves, and sessile figs. Although his plant seemed to differ from the type of *F. racemosa* his characterization was quoted by Roemer and Schultes (1817) in their edition of the *Systema*. Link (1822), writing of the Berlin Royal Gardens, cited Vahl as the author of *F. racemosa*. Link may have referred to a tree mentioned by Willdenow (1809) as growing in that place. Perhaps this was the plant which Kunth (1846, 1847) called *F. racemosa* (Vahl) Willd. and said was a doubtful species, since Kunth referred to Link.

Willdenow's edition (1806) of *Species plantarum* was the first important work to include both *F. racemosa* and *F. glomerata* Roxb. (1798). The description of the former is a mixture of characters seemingly drawn from

various predecessors; including oblong-lanceolate leaf-blades (rather like those of Lamarck's variety) and green dots (like those of Roxburgh) which he omits from his summary of Roxburgh's species. He referred to "*Alty-alu,*" and differentiated *F. racemosa,* the "grape-bearing fig," from *F. glomerata,* the "fasciculate fig," by its smaller leaves as well as its racemes. Otherwise few differences were stated. Willdenow was referred to by most later writers on *F. racemosa* and was listed as the author of that name by Persoon (1807) and Graham (1839, p. 191). Graham there reported *F. racemosa* from the Konkans in western India, but merely referred to "*Alty-alou*" and *Grossularia domestica.* On p. 190 he asked whether *F. racemosa* Willd. and "*Atti-alou*" were synonyms of *F. glomerata* Roxb., which he described apparently from life, and which also grew in the Konkans. It seems likely that both *F. racemosa* and *F. glomerata* of Willdenow were the species known as *F. glomerata* Roxb.

After 1806 reports of *F. racemosa* as an independent species were brief, partly incorrect, or suggestive of doubt as to the tree's status. About the middle of the nineteenth century the name ceased to appear except rarely and as a doubtful synonym.

HISTORY OF FICUS GLOMERATA

Roxburgh (1798) described this species from the Coromandel Coast of southeastern India. The characterization is detailed and the accompanying illustration is in color.

During the next thirty years only a few writers mentioned *F. glomerata.* Almost all of these except Hamilton (1822) were compilers who derived their information from Roxburgh and so added nothing to his work. Willdenow (1896) probably was the first to include the species, for he was credited by the editors of Roxburgh (1832) with the authorship of the name, although his description referred to Roxburgh. Willdenow is listed in several other texts as the author, but Roxburgh is cited by most writers.

After 1830 reports of *F. glomerata* increased in number and spread of distribution, and have continued to the present time. Illustrations were made by Wight (1843), Brandis (1874), and others. Specimens from Roxburgh's and from another collection were included under the name of *F. glomerata,* No. 4511 (incorrectly printed 4501) A and B, in Wallich's catalogue (1831). These have been declared correctly allocated by King and others. More recent specimens may be found in many herbaria, and living trees have been cultivated in places far removed from their original homes and of easier access. The result has been not only to increase the knowledge of the characters of the species, but to make possible the separation of several varieties (or forms), most of which were segregated by King (1887–1888).

Rafinesque (1838) placed *F. glomerata* in the subgenus *Sukeon,* which

has not survived. Miquel (1848) located the species incorrectly in the genus *Covellia* (now a subgenus). Later (1867, p. 297) Miquel transferred *glomerata* back to *Ficus*. Other synonyms will be mentioned under the alleged varieties.

Two suggested but non-valid synonyms of *F. glomerata* were *Caprificus aspera latifolia* Rumph. and *F. cunia* Hamilton. The former probably is *F. wassa* Roxb., according to Roxburgh (1832, p. 539) and Merrill (1917, p. 193). *F. cunia* is an independent species, according to Corner (1933, p. 21) and others.

Homonyms of *F. glomerata* have been allocated as follows: Wallich, Cat. no. 4511 C in part to *F. saemocarpa* Miq., according to King (1887–1888, p. 181); Blanco, to *F. minahassee* Teysm. & De Vries, by Merrill (1923, p. 58); Hort. Berol. 1846, to *F. frangulina* Kunth and Bouché, by Kunth (1846, p. 19); Hort. Buit. ex King, to *F. variegata* Blume, by King (1887–1888, p. 169); Elmer, to *F. garciae* Elmer, by Elmer (1908) and Merrill (1923, p. 52). *F. glomerata* F.-Villar is doubtful, according to Merrill (1923, p. 69).

CHARACTERS OF FICUS GLOMERATA

The principal characters of *F. glomerata* are summarized here in order that those of *F. racemosa* may be checked against them. Characters are included which belong to such so-called varieties as seem to be valid. For additional details of flowers and receptacles see Corner (1933).

Tree, usually growing near water, to 18.5 m. high, evergreen or deciduous according to location; trunk thick, often divided near or at the base, sometimes buttressed; bark thick, smoothish, gray to reddish-brown; head sometimes thin, branches erect and spreading, aërial roots small or absent; twigs bare becoming scurfy, or hairy sometimes becoming bare; latex very milky; scales of terminal buds scurfy or hairy, elongating somewhat with the opening buds, sub-persistent; leaves alternate or sub-opposite; membranous; petioles 1.5–8 cm. long, pubescent to scurfy, or remaining pubescent; blades elliptical, ovate, or ovate-lanceolate, rarely obovate; 6–20 × 2–8 cm. in size (examples: 9.5 × 4, 13.5 × 6, 15 × 5.5 cm.); apex gradually narrowed or slightly acuminate, obtuse; base rounded, or slightly and gradually narrowed with curved sides, or cuneate and obtuse; margin entire or rarely indistinctly serrate near the apex; surfaces glabrous or hairy, under surface paler than upper one, minutely dotted with spots which become pale and tuberculate when dry; one pair of basal veins making an angle of about 80°, extending $\frac{1}{3}$ to $\frac{2}{5}$ the length of the blade; 6–10 sets of lateral secondary veins, making an upper angle of 50°–60° with the primary midrib, not forking and uniting near margin into an inframarginal vein, but appearing to fade away in fresh leaves; in dry leaves seen to unite with the nearest secondary veins by transverse veinlets; an irregular reticulum and sometimes a checkered background visible in dry leaves; figs edible but not valuable; borne from tubercles on the lower part of the trunk and the main branches, on leafless, crooked, thick, long or short, jointed and bracted twigs; appearing to form fasciculate clusters or compound (rarely simple) racemes; receptacles green

to red, downy or sometimes becoming bare, about 2–5 cm. in diameter if almost globose, sometimes ovoid or obovoid and 2.5–5 cm. long, rounded at the apex or slightly umbonate with 5–6 apical bracts which close the mouth; eventually slightly depressed or truncate at the apex and usually turbinate or pyriform in general shape; base more or less narrowed into a stipe separated from the peduncle by a collar of 3 basal bracts, or the stipe absent and the basal bracts located at the base of the body of the receptacle; peduncles stout, 2 mm. to 2 cm. in length, bare or pubescent; male, female and gall flowers in the same receptacle, male flowers bearing two stamens.

The combination of clustered figs and diandrous male flowers places *F. glomerata* in the subgenus *Neomorphe*. The presence of three kinds of flowers in the same receptacle is almost unique in *Neomorphe* and so is a valuable distinguishing feature. Other significant characters are the red figs, the ovate blades which vary slightly in proportions but not much in shape, the long basal veins, the fading-away of the main lateral veins and the almost invisible smaller veins in fresh leaves, and the transverse and bent veinlets and the pale dots in dry leaves. These leaf characters are shown in most illustrations of the species. See also figure 1 A.

ALLEGED VARIETIES OF FICUS GLOMERATA

F. glomerata. The type of *F. glomerata* as described and pictured by Roxburgh (1798) may be separated from the summary above by its petioles to 5 cm. long, its elliptical blades to 16 ×6.5 cm. in size, almost equally narrowed at the ends, glabrous on both surfaces and bearing green dots on the under surface; and by its almost globose receptacles about 4 × 3.5 cm. in size, with a rounded apex closed by scales, and a rounded, rarely narrowed base separated by close bracts from a peduncle to 2.5 cm. long. The only hairiness mentioned by Roxburgh is the "down" of the receptacle. He speaks of "racemes compound, or panicled," but illustrates only the latter type.

The distribution of the typical variety is all India, including the sub-Himalayan states to the north; Ceylon, Burma, the Malay Peninsula, and Indo-China. Writers on these regions and living and herbarium specimens add the following to Roxburgh's characterization: ovate (although rather narrow) blades granulated beneath when dry, sometimes stipitate as well as pedunculate receptacles, and an immature pubescence of all parts which eventually disappears from all except the receptacles. The other mature parts are distinctly glabrous and some of them are scurfy.

F. glomerata var. *chittagonga.* Miquel described *F. chittagonga* from herbarium specimens collected in Chittagong. Kurz (1877) characterized it from that region and Burma. King named it a variety of *F. glomerata* and located it in Chittagong and Bengal; but later (1888b) called it a "definable form." As he follows this statement with a reference to var. *elongata* he may be presumed to use "form" in the sense of *forma,* and not as a vague term of classification. Gagnepain (1928) described var. *chittagonga* from Annam and Laos, Indo-China. Specimens 3953 and 11836 of the Herbarium of the Paris Museum, collected in Annam and Laos respectively by the same collector (Poilane) of whom Gagnepain spoke, and studied at the New York Botanical Garden, are probably of *chittagonga,* although labeled *F. glomerata.*

A specimen of Corner's, Singapore Field No. 26135, resembles No. 11836 and may be the original of his description (1933) of *F. glomerata.*

From the above sources *chittagonga* apparently is characterized by an ovate blade, a smaller pyriform receptacle than that of the type, and a hairy peduncle 2–8 mm. long. There is a general white-hairiness of all immature parts which eventually almost disappears, but which seems more pronounced than in the type. But three specimens of *F. glomerata* from the Punjab, seen in New York, showed a similar white-hairiness, and one of them an ovate blade. A receptacle and peduncle resembling that of No. 3953 (above) was found in *W. Koelz 4333.*

The conclusion of this paper is that *chittagonga* is not a variety but merely a white-hairy form, and that it is not confined to the regions mentioned above. Consequently its distribution has been added to those here given for the typical form.

F. glomerata vars. *miquelii* and *goolereea.* King (1887–1888, p. 174. *pl. 218 B*) created var. *miquelii,* saying only that it had leaves like those of *F. glomerata* proper and densely white-pubescent receptacles, and that it was found in dry situations over plains of India and west into the Punjab. He gave *F. goolereea* Roxb. as a possible synonym. His plate shows a leaf which slightly resembles that of the typical *F. glomerata,* and globose axillary figs. 2.5 cm. in diameter and bearing an erect crown of bracts at the apex. It is hard to imagine how a species with only axillary receptacles can be included in subgenus *Neomorphe.* Later (1888b) King omitted var. *miquelii,* although he was writing of Indian species of *Ficus.*

F. goolereea was first listed by Roxburgh in 1814 and was placed under the heading of trees having solitary or paired receptacles. The species was validly described in Roxburgh, Fl. Ind. **3**: 538. 1832. It was said to have opposite, serrate, downy, obovate leaves; and "fruits" in axillary pairs, long-peduncled, nearly globose, downy and with an elevated scaly margin. Twenty pages in this book separate *F. goolereea* from *F. glomerata.* Although this species seemed to differ from *Neomorphe* it was spoken of as a "definable form" by King (1888b), as a synonym of *F. glomerata* by a few writers, and as one of the varieties of that species by Domin (1921). No specimens have been seen by me and the allocation appears insufficiently verified by authorities.

F. glomerata var. *mollis.* Miquel described this as *Covellia mollis,* basing it on a Javan specimen. At first he declared that the receptacles were axillary, but later (1867, p. 283), having examined specimens from Sumatra and Timor he stated that the figs were mostly subracemose on leafless branches. At this time he transferred the species to *Ficus* and cited the herbarium name *F. trichocarpa* as a synonym.

When King made var. *mollis* he said only that it was pubescent on both blade surfaces and was native to Java. Later (1888b) he mentioned it as a "definable form." Koorders & Valeton (1906) accept King's variety, but also speak of it as perhaps a form of var. *elongata,* with which it is found in some stations. However, Koorders (1912) mentions var. *mollis* King, and the Atlas of Koorders & Valeton (1916, *pl. 781*) shows a diagram of the trunk of var. *mollis* which branches above the base, in contrast to one of var. *elongata* King, which divides at the base.

A specimen seen in New York, no. 1032 of *Plants of Sumatra,* W. N. and

C. M. Bangham, collectors, evidently is this variety, although labeled *F. glomerata*. The leaf has a petiole 4.3 cm. long, and a blade 15 × 5.5 cm., narrowed at each end, with almost equal apical and basal halves, and the typical veining of *F. glomerata*. There are about 10 sets of lateral secondary veins. The body of the receptacle measures about 3 × 2.5 cm., is slightly depressed at the apex, and is narrowed at the base into a peduncle 5 mm. long, which grows from a tubercle on a branched raceme. The tree, according to the label, was 12 m. tall, and the fig was light green. But specimen no. 938 of the same collection and collectors had red figs. All parts are white-hairy except the mature blades and wood.

Domin (1921) speaks of this as *F. glomerata* var. *mollis*, and other writers cite *F. mollis* Miq. as a synonym of *F. glomerata*.

F. glomerata var. *elongata* was characterized by King as having oblong, acute leaves 17.5 cm. long, and receptacles near *F. lanceolata*, but "not ridged not warted." This phrase is expressed in such poor English that it may have been misprinted. Perhaps it should read "ridged, not warted," since Koorders & Valeton (1916, *pl. 781*) show receptacles which answer that description.

Koorders & Valeton (1906 and 1916) have characterized this variety, and have allocated to it the insufficiently described and long misunderstood *F. lucescens* Blume, and *Urostigma lucescens* (Blume) Miq. Var. *elongata* has long, narrow blades like those of var. *mollis*, but glabrous or becoming so. The petioles may reach 4 cm. in length. The globose or obovoid receptacles measure about 4.5 cm. in greatest diameter, have an apex closed with five bracts and a base narrowed a little to a thick peduncle at least 1.5 cm. long. The authors state the distribution as Java and Sumatra and assert that varieties *mollis* and *elongata* are the only representatives of *F. glomerata* in Java. Domin (1921) also accepts this variety.

The position of *F. vesca*. *Ficus vesca* is an herbarium name given to an Australian tree by F. von Mueller, but published by Miquel. It has been used also by Domin (1921).

Most Australian writers, however, have called the tree *F. glomerata* Willd., and have cited *F. vesca* as a synonym. Although Domin confirmed the connection of *F. vesca* with the so-called Australian *F. glomerata* he was not sure that the latter was the same as the Indian *F. glomerata* Roxb. But Hiern (1901) applied the authorship of Roxburgh to the Australian *F. glomerata* and vindicated it by a characterization of leafless "flowering" twigs from trunk and large branches, "flowers in racemes," diandrous male flowers, and the presence of both male and female flowers in the same receptacle. The force of this last character is weakened by the statement that the female flowers all are occupied by gall insects; since it is common for male and gall flowers of *Ficus* to be found together. Nevertheless, the combination of other characters indicates the relationship of the Australian to the Indian form.

Hiern did not refer to *F. vesca*, but described receptacles of the sort illustrated by F. M. Bailey (1913, *pl. 495*). This description, taken from Daniel Solander's notes, was of a tree which had been found in New South Wales in 1770 by Sir Joseph Banks and had been given the herbarium name of *F. caudiciflora* by Solander. The text which accompanied Bailey's plate (p. 504) listed both *F. vesca* and *F. caudiciflora* as synonyms of *F. glomerata* Willd. and referred to Hiern.

But *vesca* is not a synonym of *F. glomerata* proper, for its leaves measure about 15 × 6 cm., are more nearly ovate, and more frequently have a rounded base. Its red figs measure about 2.5–5 cm. in length. They are ovoid, obovoid, or oblong, have about 10 apical bracts, and may have a short basal stipe separated by a collar of basal bracts from a peduncle about 1 cm. long. Leaves like those pictured by Bailey were seen by me in an Australian specimen in the Arnold Arboretum. There the fig was of the same shape, but had a shorter peduncle and no stipe.

The distribution of *vesca* is Queensland, New South Wales, and the Northern Territory.

COMPARISON OF CHARACTERS OF FICUS RACEMOSA AND FICUS GLOMERATA

Both distribution and the characters of the acceptable varieties of *F. glomerata* show that it is with the typical form that *F. racemosa* should be compared.

Almost all characters reported for *F. racemosa* are included in a description of the type of Roxburgh's species. Exceptions are: location in sandy soil [but Nehrling (1944) stated that *F. glomerata* in Florida grew well in dry soils], red color of cortex and latex when exposed to air, the scattered short twigs mentioned by Thunberg (but perhaps omitted by other writers because they seemed unimportant or variable), the tender soft leaves (perhaps the same as *membranous*), and the sessile figs spoken of by Vahl (but corrected by Smith in 1810). Of course the most striking difference is in the racemose clusters of *F. racemosa*. The differences in interpretation of that adjective have been already mentioned. Corner's very full description of receptacle-bearing twigs gives some suggestion of racemes, and *vesca* is said to have subracemose clusters. Unfortunately no adequate descriptions of flowers seem to have been published for *F. racemosa*.

Finally, a study of herbarium specimens and of living trees of *F. glomerata* has resulted in the finding of leaves (see figure 1 A) and figs, and even a part of a cluster which appeared like a simple raceme; all resembling those of *F. racemosa*.

ADDITIONAL EVIDENCE FROM LITERATURE

Literature furnishes evidence in addition to the characters just discussed: evidence perhaps not always conclusive, but at least significant.

1. *Atty-alu* Rheede is almost universally accepted as the basis for *F. racemosa*. It was located on the southwest coast of India not too far from the latitude of the Coromandel Coast on the southeast. *F. glomerata* now has been reported from most sections of India, including the south and the Bombay region.

2. *Atty-alu*, when run through Corner's key to Malayan species of *Covellia* and *Neomorphe*, the two subgenera of *Ficus* which are characterized

by clusters of figs on trunks and branches, leads to *F. glomerata*. No other species there described has its combination of size and shape of receptacle, and length of peduncle.

3. *Atty-alu* is suggested or cited as a synonym of *F. glomerata* by Hamilton (1822), who said that Roxburgh so considered it; by Kosteletzky (1831), Graham (1839), Pritzel (1855, 1866), and Balfour (1862, 1870).

4. Trimen (1885) said that *Atti* is a vernacular name in Ceylon for *F. glomerata*.

5. Very few scientists stated that they had seen *F. racemosa* L.

6. The reports of that species in botanical gardens were unsatisfactory.

7. *F. racemosa* Willd. (which, however, may not be *F. racemosa* L.) is suggested or cited as a synonym of *F. glomerata* by Hamilton (1822), Graham (1839), and Balfour (1862, 1870).

8. *F. racemosa* Aiton (1813) was said by Hamilton (1822) to be *F. glomerata*.

9. *F. racemosa* Hb. Wight in Wall. Cat. n. 4549 was said by King (1887–1888, p. 173) to be *F. glomerata* Roxb.

10. *F. racemosa* Hb. Rottler in Hb. Kew was said by King (1887–1888, p. 183) to be *F. glomerata* Willd.

11. Reports of *F. racemosa* began to die out many years after *F. glomerata* was first described.

CONCLUSIONS

1. Evidence from descriptions of *Atty-alu* Rheede, the prototype of *Ficus racemosa* L.; from descriptions and reports of *F. racemosa;* from descriptions, herbarium specimens and observation of living trees of *F. glomerata;* and from opinions expressed in literature as to these species proves that *F. glomerata* Roxb. belongs to the species *F. racemosa* L.

2. The reasons for the disappearance from botanical literature of *F. racemosa* probably are: the scarcity of first-hand observation of the species, the emphasis in descriptions on the cluster as a raceme and the change in original meaning of *racemus* from a usually grape-like cluster, and the announcement of the species *F. glomerata* in which the fruiting cluster almost never was a raceme.

3. Four varieties of *F. racemosa* are here recognized. Var. *typica*, the original *F. glomerata*, corresponds to *F. racemosa* L. It is native to India, Ceylon, and the countries east of the Bay of Bengal. It is eventually an almost entirely glabrous tree, with ovate or elliptical leaf-blades. A form, *chittagonga*, is more persistently hairy. Var. *vesca* is native to Australia. It has ovate blades and ovoid or oblong, usually stipitate, figs. The varieties of Sumatra, Java and Timor are *mollis* and *elongata*. They are characterized especially by their long narrow elliptical blades. The former variety is hairy; the latter eventually glabrous.

4. The alleged varieties *miquelii* and *goolereea* are rejected.
5. The synonym of *F. racemosa* and its varieties is as follows:

FICUS RACEMOSA L. Sp. Pl. 1060. 1753.

FICUS RACEMOSA L. var. **typica** Barrett, var. nov.

Atty-alu Rheede, Hort. Mal. **1**: 43. *pl. 25*. 1678.

Ficus malabarensis folio oblongo, acuminato, fructu vulgari aemulo Syen, *in* Rheede, Hort. Mal. **1**: 44. 1678.

Ficus foliis ovatis acutis integerrimis, caule arboreo, fructu racemoso L. Amoen. Acad. **1**: 30. 1749.

Ficus glomerata Roxb. Pl. Corom. **2**: 13. *pl. 123*. 1798.

Covellia glomerata (Roxb.) Miq. Lond. Jour. Bot. **7**: 465. 1848.

? *C. racemosa* (L.) Walp. Ann. **1**: 731. 1848–1849.

F. chittagonga Miq. Ann. Mus. Bot. Lugd.-Bat. **3**: 228. 1867.

F. glomerata var. *chittagonga* (Miq.) King, Ann. Bot. Gard. Calcutta **1**: 174. *pl. 219*. 1888.

FICUS RACEMOSA var. **elongata** (King) Barrett, comb. nov.

F. lucescens Blume, Bijdr. 444. 1825.

Urostigma lucescens (Blume) Miq. Fl. Ind. 1^2: 341. 1859.

F. glomerata var. *elongata* King, Ann. Bot. Gard. Calcutta **1**: 174. 1888.

FICUS RACEMOSA var. **mollis** (King) Barrett, comb. nov.

Covellia mollis Miq. Lond. Jour. Bot. **7**: 466. 1848.

F. mollis (Miq.) Miq. Ann. Mus. Bot. Lugd.-Bat. **3**: 283. 1867. (Not Vahl.)

F. trichocarpa Hb. Mus. Paris. ex Miq. Ann. Mus. Bot. Lugd.-Bat. **3**: 283. 1867.

F. glomerata var. *mollis* King, Ann. Bot. Gard. Calcutta **1**: 174. 1888.

FICUS RACEMOSA var. **vesca** (Muell. ex Miq.) Barrett, var. nov.

F. vesca Muell. ex Miq. Jour. Bot. Néerl. **1**: 243. 1861.

F. glomerata of Bentham and many other writers on Australia.

F. caudiciflora Solander MS ex Hiern, Jour. Bot. **39**: 5. 1901.

The library work for this paper has been done mostly at the New York Botanical Garden. Herbarium specimens have been examined there and at the Arnold Arboretum, the State Agricultural Experiment Station at Gainesville, Florida, and the United States National Herbarium in Washington. Living trees have been studied at the United States Plant Introduction Station at Chapman Field, south of Coconut Grove, and on the estate of Mrs. Charles T. Simpson in Miami, Florida. I am grateful for the permission to use these facilities and for the help given me by those in charge of them.

MONTCLAIR, NEW JERSEY

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STUDIES IN THE CARYOPHYLLACEAE—I

BASSETT MAGUIRE

To make them immediately available for use by Mr. I. W. Clokey for his Flora of the Charleston Mountains, the following proposals of new entities or combinations have been extracted from more detailed papers. The fuller supporting considerations will appear as publication date becomes available for them.

Arenaria filiorum Maguire, sp. nov. Plantae annuae; caulibus tenuis, numerosis, 2–5 cm. altis; foliis 5–10 mm. longis, triquetribus, subcrassulis, 1-nerviis, obtusis; inflorescentibus 1-pluribus floribus; cymis non symmetricalibus; sepalis 3.5–4.8 mm. longis, ovato-lanceolatis, valde 3-nerviis, stylibus 3 (4); capsulis chartaceis, ovatis, ad basim dehiscentibus; seminibus numerosis 0.7–1.0 mm. longis.

TYPE: Common, gravelly beach, Navajo Lake, Iron County, Utah, July 13, 1940, *Maguire 19472*. New York Botanical Garden.

ARENARIA CONGESTA Nutt. ex Torr. & Gray var. **charlestonensis** Maguire, var. nov. Caulibus 10–12 cm. altis; foliis 1.0–1.5 cm. altis, 0.5–0.8 mm. latis, recurvatis vel aculeatis, basilaribus; inflorescentibus dense congestis; sepalis 4.5–5.5 mm. longis, acutis, pungentibus.

TYPE: Harris Spring Summit Road, 18 mi. south Kyle Canyon, 8500 ft., Charleston Mountains, Clark County, Nevada, August 2, 1938, *Train 2256*. New York Botanical Garden.

ARENARIA MACRADENIA S. Wats. subsp. **macradenia** Maguire, subsp.nov. *A. macradenia* S. Wats. Proc. Am. Acad. **17**: 367. 1882, as to type.

ARENARIA MACRADENIA S. Wats. subsp. MACRADENIA Maguire var. **macradenia** Maguire, var. nov. *A. macradenia* S. Wats. Proc. Am. Acad. **17**: 367. 1882, as to type. *A. congesta* var. *macradenia* (S. Wats.) M. E. Jones, Proc. Cal. Acad. II. **5**: 626. 1895. *A. Fendleri* var. *glabrescens* S. Wats. in Bot. King's Expl. **5**: 40, in part. 1871.

ARENARIA KINGII (S. Wats.) M. E. Jones subsp. **rosea** Maguire, subsp. nov. Caudicibus pauciramosis; inflorescentibus strictis, paucifloribus; petalis roseis.

TYPE: Hilltop, yellow pine belt, Lee Canyon, 2600 m., Charleston Mountains, Clark County, Nevada, August 4, 1935, *I. W. Clokey 5560*. New York Botanical Garden.

THE NEW YORK BOTANICAL GARDEN
NEW YORK

INDEX TO AMERICAN BOTANICAL LITERATURE

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(exclusive of fungi)

(See also under Genetics: **Love**; under Paleobotany: **Bradley**.)

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